NATURE

No. 3838 SATURDAY, MAY 22, 1943 Vol. 151

CONTENTS

	Page
Future of the Continuation School	567
Biringuccio in English. By Prof. John Read, F.R.S.	569
The Making of an Engineer. By Prof. Willis Jackson	571
Theory and Practice of Heat Engines. By Dr. O. A. Saunders	571
Copernicus and the Heliocentric Theory. By Dr. H. Spencer Jones, F.R.S.	573
The Work of Copernicus	576
Co-enzymatic Reactions. By Prof. J. K. Parnas	577
Botany in India. By Sir Geoffrey Evans, C.I.E.	580
Obituaries:	
Prof. Warrington Yorke, F.R.S. By Prof. D. B. Blacklock, C.M.G.; Lieut.-Col. S. P. James, C.M.G., F.R.S.	581
Mr. W. Trevor Watson, K.C. By G. S. W. Marlow	582
News and Views	583
Letters to the Editors:	
New X-ray Evidence on the Nature of the Structural Changes in Cold-worked Metals.—Dr. W. A. Wood	585
Mechanism of Biological Action of Vitamin K and its Synthetic Analogues.—Prof. M. M. Shemiakin, L. A. Schukina and J. B. Shvezov	585
Counteracting Sulphonamide Inhibitors.—Dr. W. K. S. Wallersteiner	586
Amoeba lescheræ.—Dr. Monica Taylor and Catherine Hayes	587
Potatoes and War Economy.—Dr. Nicholas Polunin	587
Map Construction from Aerial Photographs.—Dr. G. D. Hobson	588
H. L. Callendar and the Theory of the Liquid State.—Dr. R. S. Silver	588
Science, Common Sense and Decency.—William P. D. Wightman; E. Denne	589
Improvement of the Nitrogen Status of Soils and the Origin of Soil Nitrogen. By Prof. N. R. Dhar	590
The Tennessee Valley Authority: An Experiment in Regionalism. By K. S. Lomax	592
Insulation of Heating Systems	593
Preparation of Teachers in Health Education	593

Editorial and Publishing Offices
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London

Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone: Temple Bar 1942

The annual subscription rate is £4 10 0, payable in advance, Inland or Abroad

All rights reserved. Registered as a Newspaper at the General Post Office

FUTURE OF THE CONTINUATION SCHOOL

ONE of the subjects that is exercising the minds of members of the Board of Education at the present time are the details of a system of continued education on lines calculated to meet the needs of individual adolescents and to make them more useful members of the community. So long ago as 1562 a national system of training for young people in all trades was introduced in Great Britain with the passing of "The Statute of Artificers". This made apprenticeship compulsory under the guild system, and although the law made no provision for the enforcement of this Act, the position of the guilds and, consequently, the care of young workers were considerably improved. It was a black period in British history for young people when the concentration of industry led to the repeal of "The Statute of Artificers" in 1814. To-day, for the second time within twenty-five years, a world war has brought about a quickened interest in part-time education for the adolescent, and now educationists are eagerly awaiting an overdue Education Bill with the Board's proposals for dealing with the problem.

The Fisher Act of 1918 empowered local education authorities to set up part-time day continuation schools for youth in industry, with an age limit of 14–16, to be raised to 18 at the end of seven years. One education authority alone, Warwickshire, has found it possible to adopt this recommendation and to-day we have but one statutory day continuation school in Great Britain (Rugby). In addition, there are twenty-six voluntary day continuation schools which are run under the ægis of local education authorities, and four schools which are conducted solely by the employers and are quite independent of the local education authorities. The combined experiences of these schools, which developed through the imagination and initiative of a number of far-sighted men and women, will need to be carefully weighed before plans for the future are formulated and laid down.

The British Association for Commercial and Industrial Education is an organization which speaks with considerable authority on the role of education in industry. It was a timely choice that prompted its members to take as their subject at a recent conference the place of part-time day education for new entrants to industry. The report* of its conference has now been issued and contains a useful summary of the experiences already gained in this field of work and offers many valuable suggestions that deserve close study.

Since the time when the Fisher Act made provision for a system of continued education, the supporters of these schools have been, as previously indicated, a very small minority. In 1938 only 40,000 out of two million children attended any classes during their working hours. Even to-day, employers who have seen in the day continuation school a means of easing the tremendous break between school and work

* Part-time Day Education for the Adolescent. A Report of a Conference held on September 29, 1942, by the British Association for Commercial and Industrial Education. 1s.

for the young boy and girl, are still referred to by many educationists as "enlightened" and "progressive", although the epithets bestowed upon them by some of their fellow-employers suggest that they have lost their commercial or industrial acumen and that they are dabbling with experiments which have no relation to the successful running of their businesses. This point of view met with little support from Mr. Churchill in his broadcast speech of March 21, 1943, when he declared that "after school-time ends we must not throw our youth uncared for and unsupervised on to the labour market, with its 'blind alley' occupations which start so fair and often end so foul. We must make plans for part-time release from industry, so that our young people may have the chance to carry on their general education and also to obtain a specialized education which will fit them better for their work".

What, then, are the advantages of these schools which are soon to be adopted as an integral part of the national educational system? It will be apparent that any attempt to separate advantages that will accrue to the employer from those of benefit to the employee is almost impossible. A worker who is able to focus his full mental powers upon his particular job will inevitably be more acceptable to his employer than an employee who is uninterested and perhaps antagonistic towards his employment. Similarly, the employee who is mentally alert will enrich his experiences not only at his work-place but also in his leisure hours.

There are other advantages which are not quite so obvious. Where the school is closely linked with the firm, for example, and where the school staff know and are known by the firm's staff, the employer is able to get an independent opinion upon ability, character and general health from a staff who consider people for what they are rather than for what they can do in any one department. It is important that this opinion should come from the only department which regularly sees all the junior employees of the firm; a foreman can give an opinion only upon those few with whom he comes in contact. In cases of promotion, change of occupation, removing square pegs from round holes, etc., the school report would be most useful and able to effect changes which would render dismissal impotent.

Benefits which show themselves in an absence of trouble are difficult to assess, because of their negative character, but these can still be seen on the physical side. In a well-run day continuation school, the students would be kept under constant medical supervision. Physical education would form a regular feature of the weekly activities, while games and other outdoor recreational pursuits would naturally be encouraged. During the years of bodily development these activities would almost invariably result in good physiological tone, which in itself is a safeguard against excessive accidents in the works as well as an effective check to absenteeism through sickness and ill-health.

Besides these direct advantages to the individual and his or her employer, there are those which arise from a person's duties and responsibilities in the social framework of national life. A good workman is not necessarily a good citizen; but a good citizen is more likely to be a good workman than a bad citizen. This is highly significant when one remembers that the professional and skilled classes in industry are a very small and still decreasing proportion. As mechanization proceeds still further, semi-skilled workers will need greater and greater provisions for their training, if we are not to produce a type of individual whose personality and character become but a pale shadow of his repetitive work.

The form that part-time day continuation schools, or, as they are more likely to be called, colleges, will probably take can best be discussed by examining the already existing ones. These are of three types: those run by the local education authority; those run conjointly by the local education authority and a works; and the purely works school. While the latter may be possible for the bigger firms, it is to the local education authorities that we must look for the encouragement of institutions that will meet the demands of the smaller and diverse types of industrial organizations. The day continuation college controlled by the local education authorities will possess at least one considerable advantage over that administered by a works. It will attract people drawn from various sides of industry; the clerical worker and the technician should more easily develop mutual understanding in their common education.

A vexed question, on which the Board's pronouncement is awaited with keen interest, is the amount of time that is to be given to education each week. Under the Fisher Act, youths were to be released from industry to continue their education for a period of eight hours weekly in a year of forty weeks. This is the practice at Rugby and other existing day continuation schools, particularly those in London. In Strode, Somerset, however, a day continuation school for shoemaker employees has been conducted on a half-time basis since 1926 and, according to one of the directors, Mr. J. A. Clark, possesses many advantages over the two half-days per week system. The latter system was tried at Strode but caused considerable annoyance and friction in the factory because of the difficulty of organizing a department to release boys and girls for odd periods. Under the present Strode system each vacancy in the factory is filled by two boys or girls. When one works the other goes to school, and vice versa. This school has now been in action for fifteen years and the directors are unanimous as to its efficacy and value.

Other observers at this conference, however, were strongly opposed to half-time schools, mainly because of the difficulties of organization and administration that would be involved as well as the fact that the employment of a duplicate number of juniors would involve a lessening of opportunities for promotion at the age of eighteen or twenty, with the inevitable consequence of establishing a certain amount of 'blind alley' employment. At the present time, too, facilities for half-time continued education must necessarily be restricted by the limited amount of adequate and suitable accommodation. This is a problem which could be solved within a decade,

however, and should not be presented as a too formidable argument against the half-time system.

Another and very real difficulty that will arise from the introduction of part-time education is the inconvenience caused to small firms by the release of boys and girls from their employment for a certain period each week. The same type of difficulty arises in a single department of a large firm, but it has already been seen in practice that by careful organization, continued good-will and constant consultation between the employer and the school, this problem is not incapable of solution.

The content of the school curriculum will also demand close scrutiny. Here, fortunately, the sponsors of the continued education movement speak with one voice as to the general policy, and, presumably, their experiences will guide the Board in its considerations. The education of new entrants to industry, according to Dr. F. H. Spencer and other speakers at this conference, should comprise : (*a*) a technical element, including craftsmanship and its scientific foundations ; (*b*) the consolidation of the general education of the students, their literacy, their knowledge of the humanities and of science ; and (*c*) some efforts to explain to young people the religion of their time and civilization. Above all, boys and girls should be given the opportunity of attaining complete self-fulfilment and the happiness that accompanies it, by finding the work that they are best fitted to do.

Obviously, the establishment of day continuation colleges will necessitate a considerable increase in the number of teachers in Great Britain. A cautious statement from the Board suggests that to meet all the demands that will be made upon them after the War, some 70,000 new teachers will be required. The National Union of Teachers puts the figure nearer 120,000. Under pre-war methods of training some 25,000 new teachers became available annually. Other sources of recruitment will thus have to be explored. Industry itself will probably supply the needs of adolescents in industry more effectively than the strictly academic products of the training college and the university training department. The latter might well spend part of their training in a factory if they intend to make teaching in a day continuation college their life's work. This would be an invaluable experience for those suited to the job, while those not suited would probably be deterred in good time. Moreover, intending teachers in these colleges should be keenly interested in the service of youth and prepared to devote much of their leisure time to extra-curricular activities. The day continuation college would then become the centre of the young person's educational and social life and would go far towards solving the difficulties experienced by the organizers of the so-called Youth Movement to-day.

There can be little doubt that the introduction of day continuation colleges will do much to secure the *rapprochement* between industry and education which is essential if Great Britain is to retain its position as a leading industrial and commercial power. An announcement as to their scope and organization within the national scheme of education will be greeted with keen interest.

BIRINGUCCIO IN ENGLISH

The Pirotechnia of Vannoccio Biringuccio

Translated from the Italian, with an Introduction and Notes, by Cyril Stanley Smith and Martha Teach Gnudi. (Publication sponsored by the Seeley W. Mudd Memorial Fund.) Pp. xxvi+476. (New York : American Institute of Mining and Metallurgical Engineers, 1942.) 5 dollars.

IT is generally acknowledged that the standard medieval work on mining and metallurgy is Agricola's "De Re Metallica", first published in 1556, at Basle. This handsome folio volume, beautifully printed and produced by the famous house of Froben, with a wealth of artistic and informative woodcuts, forms a noble ornament to any library, quite apart from its scientific value. In his preface to the work, dated 1550, Agricola wrote : "Recently Vannucci Biringuccio, of Sienna, a wise man experienced in many matters, wrote in vernacular Italian on the subject of the melting, separating, and alloying of metals . . . by reading his directions, I have refreshed my memory of those things which I myself saw in Italy". This is a reference to "De La Pirotechnia", written by Vannoccio Biringuccio and first published in 1540, at Venice. In reality, Agricola's indebtedness to the earlier work was very considerable, seeing that he drew from it the gist of his descriptions of the distillation of mercury and sulphur, the manufacture of glass and steel, and the crystallization of saltpetre, alum, salt, etc.

Of the surprising number of printed works issued before 1500, few dealt with science and none with metallurgy. Biringuccio's classic was the first work on practical metallurgy to be printed. Although the "Pirotechnia" appeared in six Italian and three French editions within 138 years, and was used and valued by practical men of the calibre of Robert Hooke, yet in the field of metallurgical literature it has always been overshadowed by Agricola's famous work : this result may be ascribed largely to the squat and unattractive format, the inferior illustrations and literary style, and the vernacular language of the "Pirotechnia". It is significant that "De Re Metallica" was published in a German edition in 1557, whereas no German version of the "Pirotechnia" appeared until 1925.

For the advent of an English edition, "De Re Metallica" had to wait 356 years, and the "Pirotechnia" 402 years. The volume now under notice, based on the original publication of 1540, is the first complete version in the English language of Biringuccio's masterpiece, although two fragments of it were 'Englished' in the sixteenth century. Richard Eden, indeed, finished an English translation of the first twenty-two chapters in 1552, but at that juncture was unfortunately persuaded to lend his manuscript to a friend who failed to return it. Somewhat later, as Dr. Smith points out, most of Book X was reproduced without any acknowledgment, together with copies of some of Biringuccio's illustrations, in Peter Whitehorn's celebrated military work of 1560, entitled "Certain waies for the orderyng of souldiers in battelray . . . and more ouer, howe to make saltpeter, gunpoulder and diuers sortes of fireworkes or wilde fyre . . ."

Fate has certainly dealt unkindly with the "Pirotechnia", and the book's undoubted influence on later metallurgical publications was mainly indirect. Even now there is no definitive edition of the Italian

text; for although Aldo Mieli published the first volume of a critical edition in 1914, with valuable annotations and an introductory account of Biringuccio and his background, the work ceased at that point. Since 1925 the annotated German translation of Otto Johannsen has been the most useful version available; this was well produced and carefully edited. Now, at long last, justice has been done in the English tongue to this venerable pioneering work in the domain of metallurgy and related branches of science.

Vannoccio Biringuccio, the son of an architect of Siena, was born there in 1480. Like Benvenuto Cellini, twenty years later, he was probably trained locally as a craftsman, in an age which drew no essential distinction between the industrial arts and the fine arts. The knowledge which he records in the "Pirotechnia" was gained largely in his younger days, in the course of extensive travels in Italy and Germany. His chequered career was bound up with the fluctuating fortunes of the Sienese family of Petrucci: in 1516, and again in 1526, he was declared a rebel and exiled from Siena. Later, however, matters were composed, and in 1531 Biringuccio became a senator of his native city. In the years that followed he was appointed architect and director of the Opera del Duomo, besides being called upon to cast arms and build fortresses at Venice and elsewhere in Italy. As regards the "Pirotechnia", internal evidence indicates that it was written after 1534. Eventually, in 1538, Biringuccio took charge of the papal foundry and munitions in Rome. Soon afterwards he died, either in 1538 or early in 1539.

The "Pirotechnia", no less than his other activities, shows that Biringuccio's outlook was emphatically practical. He was strongly individualistic and relied upon his own observation, experience and commonsense. Like his contemporary, Paracelsus, he had little respect for the orthodoxy of a hoary and enslaved literature, or for "the authority of hearsay in place of reasons for possible success or facts that can be demonstrated", as he phrased it; "I have no knowledge other than that gained through my own eyes," he wrote. Thus the "Pirotechnia" is a source book, full of first-hand descriptive accounts of arts and processes depending upon a practical knowledge of ores, metals and salts. "It was men like Biringuccio," says Dr. Smith in his introduction, "the practical metalworkers, dyers, pottery makers, alum boilers, and kindred artisans, who accumulated the basic facts for a chemical science during the period in which learned men of church and university were engaged in lengthy but barren theological disputation. The artisans were the true scientists of this period."

Biringuccio had no sympathy with the hazy doctrines of the alchemists, although he was ready to give credit to the 'puffers' for an occasional useful discovery made in the laboratory. He pokes gentle fun at the loudly proclaimed virtues of potable gold and the philosopher's stone: "their fantastic writings are but masked shadows", he writes of alchemical lucubrations; "the best thing to do is to turn to the natural gold and silver . . . rather than that of alchemy, which . . . has never been seen by anyone". In bidding adieu to the alchemists he exclaims characteristically that when considering them his thoughts "press forward in a throng like dogs happy in the chase, each one desirous of coming out first".

The "Pirotechnia" opens with an account of ores of the common metals, followed by a description of the making of steel and brass. The so-called semi-minerals are next discussed: these include quicksilver, sulphur, antimony, arsenic, common salt, borax, rock-crystal, gems, glass, many ores, and salts in general. The numerous operations then described in detail include the assaying and smelting of ores; the separation of gold from silver; alloying; casting; the melting of metals; the arts of the goldsmith, coppersmith, pewterer, potter, etc.; the manufacture of saltpetre, gunpowder and fireworks to be used in warfare and for festivals. There are eighty-four illustrations, the great variety of which may be gauged from such titles as the following: miners' tools; an assaying laboratory, showing balances, muffle furnace for cupelling, etc.; the bell foundry; furnace for welding cracked bells; wind furnaces; treadle-operated bellows; machine for boring guns; cucurbits, alembics, and receivers; distillation of alcohol; bell for collecting oil from burning sulphur; wire drawing; goldbeaters at work; the pottery; brick and lime kilns; loading and aiming a gun; fire pots with slings, and incendiary arrows; girandoles.

Of all the editions of the "Pirotechnia" this one does most justice to the original work. The translation has been accomplished with great care, and the introduction, annotations, appendixes and bibliography leave little to be desired. The book is a sumptuous and beautiful production, with a large page, clear type, sharp illustrations, and wide margins. Mistakes there are, to be sure (such as "Charles Pack" for "Christopher Packe", "J. H. Hopkins" for "A. J. Hopkins", and "Reed" for "Read"); but these are not numerous. It is not too much to say that this edition will take rank as the standard rendering of the "Pirotechnia" for the English-speaking world, and that Smith and Gnudi have done for Biringuccio in 1942 what the Hoovers achieved with such distinction for Agricola in 1912.

JOHN READ.

THE MAKING OF AN ENGINEER

The Making of an Engineer

Pp. 82. (Hebburn-on-Tyne: A. Reyrolle and Co., Ltd., n.d.) n.p.

SEVERAL groups of people operating under a variety of auspices have produced reports during recent months dealing with the education and training of young people prior to, and during, their employment in industry. In the main, these reports have dealt with the principles which must be adhered to in the intended reorganization of the pre-war system obtaining in Great Britain, but the precise manner in which the various recommendations will be put to practical effect remains in general to be formulated. This recent publication of Messrs. Reyrolle differs in that it gives a practical example; an example which illustrates the manner in which an industrial concern, which recognizes and accepts responsibility for ensuring the continued education and effective practical training of its recruits, can contribute to the national well-being—while at the same time, of course, ensuring its individual prosperity.

Fortunately this firm is not the only one in Great Britain which has made such a contribution, and there is good evidence to show that many others are making preparations to this end. For some years past most of the large electrical engineering concerns,

in particular, have organized schemes of practical training embracing their several grades of recruit—from the elementary school boy to the university graduate—along lines similar to those described, though in few cases have the arrangements been so comprehensive.

The Reyrolle firm has evidently taken particular care in providing for the up-grading of its more promising trade apprentices. Part-time day release to attend courses of technical instruction at the local colleges is granted to all who are able to derive full benefit from them, and the broadmindedness of the firm may be judged further from the statement that it affords "particularly favourable opportunities" to those so inclined "of securing appointments elsewhere, at home or abroad, after their training". This willingness to regard themselves as training grounds for the industry as a whole is characteristic of the large electrical engineering concerns of Great Britain. It is an excellent augury for the future prosperity of this industry and an inspiring example to others not yet so enlightened.

The information provided in the publication does not permit a critical analysis of the actual training arrangements, but it seems that the whole of the practical experience is gained in the main workshops. In the opinion of an increasing number of people, special apprentice workshops, separated from the productive activity, should be provided for the purpose of ensuring a broad preliminary acquaintance with all significant manual and machine operations. Little is said, either, about the procedure adopted in the selection of recruits to the various forms of apprenticeship; the importance of this problem is being recognized increasingly, and one would like to know the extent to which use is made of psychological tests, in relation particularly to the trade apprentices.

The publication has been prepared in a most attractive manner; it is very fully illustrated with examples of engineering practice, and after reading it few will question the correctness of an early statement that "to anyone with the right aptitude engineering offers the possibilities of a rich and interesting life".

WILLIS JACKSON.

THEORY AND PRACTICE OF HEAT ENGINES

The Theory and Practice of Heat Engines
By D. A. Wrangham. Pp. xii+756. (Cambridge: At the University Press, 1942.) 50*s*. net.

IN many respects this is an outstanding book, well produced and exceptionally well illustrated, giving a clear account of the usual subject matter, together with chapters on heat flow, combustion, flow of fluids, and also on modern boiler plant, turbo-power plant, and the elements of economics of plant layout. The practical aspect is kept constantly to the fore, and plenty of numerical examples given at every stage. As a general criticism, however, the book, while falling short of a comprehensive treatise, is on the expensive side for students, especially since the treatment makes no particular claim to novelty.

To write a comprehensive account of the theory and practice of heat engines, including the theory treated as a branch of thermodynamics, and all the up-to-date practical developments, would be a big task, certainly running to more than one volume, and each of the practical sections, for example, internal combustion engines, would have to bear comparison with books devoted entirely to the one branch. A single volume must, therefore, always be open to criticisms of omission, and it becomes a question of what to put in and what to leave out. For degree students, however, Mr. Wrangham covers the field well, although for so large a volume the theoretical sections are rather sketchy.

Opinions among teachers may differ as to how far students of heat engines should be acquainted with the wider field of thermodynamics, but few would deny the importance of a sound introduction to fundamentals. On the whole the book is satisfactory in this respect, but there are some grounds for criticism. This raises the whole question of haziness in fundamentals in books on heat engines, and the following remarks apply no more to the present book than to many others. Some well-known writers, for example, continue quite incorrectly to represent irreversible processes, such as unresisted expansion, by a curve on a pressure-volume diagram, and speak of the area beneath the curve as 'work wasted', when in fact the work is non-existent. Heat and temperature are not clearly distinguished, the term 'adiabatic' is used in two different senses, sometimes as a quite unnecessary alternative to 'isentropic', and sometimes to denote any process where no heat is interchanged with the surroundings, thus including an irreversible process such as throttling. Again, the wide use of the term 'pressure energy' tends to mislead the beginner, who may picture a specific gas property akin to the potential energy of a coiled spring, when actually, for any given temperature, a perfect gas has the same energy whether it occupies a small volume at high pressure, or a large volume at low pressure. It is just this distinction which differentiates thermodynamics from mechanics. Too narrow an outlook is perhaps responsible for some of the confusion, and is scarcely likely to lead to the best teaching. Common agreement as to the meaning of terms would also help.

Mr. Wrangham introduces the kinetic theory of gases at the outset, and his brief treatment is sound except for one or two loose statements in which the statistical nature of this theory is not made clear. Thus, on p. 23, referring to diffusion, he says, "the molecules of one gas will invade those of the other and gradually they will all acquire a common velocity", whereas in the completely mixed state it is the mean kinetic energies of the two gases which are equalized. Again, on p. 25, it is stated that "the kinetic energy of all molecules at the same temperature is the same, whatever their mass". Such statements, arising from the author's use of an "average" molecule possessing the root mean square velocity, may mislead the student to think of an individual molecule as possessing temperature, and to obscure the important difference between the translational kinetic energy of a mass of gas, which is completely convertible into work, and the mean kinetic energy of random molecular motion, or heat, which is only completely convertible into work by a reversible expansion down to absolute zero temperature. In a volume of this size one might reasonably expect greater attention to these finer points.

Nevertheless, to the student who can afford the time and money, and who is already to some extent familiar with fundamentals, the book can be recommended and should prove very valuable.

O. A. SAUNDERS.

Switchgear Practice

By Arthur Arnold. Pp. iv+238+27 plates. (London: Chapman and Hall, Ltd., 1942.) 22*s*. net.

A BOOK on this subject, planned as this one is, has been needed for a long time, for while there is an extensive literature in the form of articles and papers presented before the professional engineering institutions, contributions in book form are relatively scanty. Those which have appeared have generally been written by and for switchgear designers, so that one having a particular appeal for the user-engineer fills a distinct gap which has existed in the technological book world.

The scope of the work is wide, ranging as it does from motor starters to high-rupturing capacity circuit-breakers. The treatment accorded to it is based upon a presentation of the main principles controlling the selection of suitable gear for the many purposes which arise in practice; design data and constructional details are omitted, as being outside the conception of the book. The first four chapters deal with D.C. breakers, motor starters, controllers and switchboards, the rest of the book describing A.C. breakers of small and medium sizes and those for heavy-duty service, A.C. busbars, arc control devices, interlocks, testing, switchgear protective devices, instrument and control boards, lightning arresters, fire prevention and protection, and oil-less circuit breakers.

There is a surprising omission of reference to the pioneer research and development done by the British Electrical and Allied Industries Research Association on gas-blast circuit-breaker development, and no record in the bibliography of the published work of Wedmore, Whitney and Bruce of that body. Such work may not be 'recent', but it is too fundamental to be ignored, and British engineers have led the way in this important phase of large power control. Methods of calculating network fault currents might also, with advantage, have been given in the book—it is a feature of prime importance to the user and one which he needs to predetermine when specifying the requirements of a circuit breaker. The book, however, constitutes a useful survey of modern switchgear practice and it should enjoy a ready acceptance by operating engineers.

Air Navigation

British Empire edition, by Lieut.-Comdr. P. V. H. Weems. Revised and edited by Arthur J. Hughes and P. F. Everitt. Second edition. Pp. xxi+519. (London: McGraw-Hill Publishing Co., Ltd.; New York: McGraw-Hill Book Co., Inc., 1942.) 35*s*.

AS a practical manual of air navigation, this book can be thoroughly recommended. It describes the methods of navigation by pilotage, dead reckoning, radio position finding and celestial observation, with a comprehensive account of the instruments employed and of the various tables for facilitating the determination of position. It contains little in the way of mathematics and does not go at all deeply into the theory of the methods. The outlook is essentially practical rather than theoretical. An unusual feature in a work of this sort, but one of undoubted value for the air navigator, is an excellent outline of meteorology by Dr. Sverre Petterssen. The book contains a large number of figures, diagrams and illustrations of various instruments and forms a useful work of reference.

There are a few statements which are inaccurate or misleading; but it is not correct, as stated on p. 75, that a magnetic compass points towards the north magnetic pole, nor is it true that the changes with time in the magnetic variation are due primarily to the movement of the earth's magnetic poles. The statement on p. 330 that "better navigation can now be done by using two good second-setting watches, checked daily, than is possible with two or three high-class chronometers when these are checked only occasionally", is not pertinent to the relative time-keeping properties of watches and chronometers. In these days when radio time signals are generally available, there is no reason why chronometers should be checked only occasionally. Though a good performance can be expected from a high-grade watch, this affords no justification for belittling the better performance of which a chronometer is capable. H. S. J.

Food, Health, Vitamins

By Prof. R. H. A. Plimmer and Violet G. Plimmer. Ninth edition. Pp. vii+193. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1942.) 7*s*. 6*d*.

Vitamins and Minerals for Everyone

By Alida Frances Pattee. Pp. xviii+242. (New York and London: Putnam and Co., Inc., 1942.) 10*s*. net.

"FOOD, HEALTH, VITAMINS" has reached its ninth edition and is so familiar as to need little further notice. It has made its way on merit and to-day is acknowledged to be an excellent introduction to the subject of nutrition. New material has been added which gives the results of various wartime nutritional experiments, and the numerous tables have been overhauled and brought up to date.

"Vitamins and Minerals for Everyone" is a queer mixture. It has been written and arranged "for both the profession and the laity", and has catered happily for neither. The laity is provided for by some dramatic interludes which remind one of the commentaries of a Wild West serial produced in Hollywood. The contribution "for the profession" includes an account of the part played by vitamins and trace elements in human nutrition together with a valuable appendix of relevant nutritional tables.

Biology Staining Schedules for First Year Students

By R. R. Fowell. Pp. 20. (Swansea: The Author, Swansea Technical College, 1943.) 1*s*. 6*d*.

THIS little laboratory manual presents in a clear and compact form the practical directions necessary to enable the student to master a limited number of staining techniques, which have been chosen as those most suitable for students or senior pupils working through courses for the Intermediate B.Sc. or B.Pharm., First Medical or Higher Certificate.

A preliminary section deals with such matters as the classes and uses of stains. Tables are given of the chief staining reagents and some advice on staining, which might have been advantageously extended. This is followed by five pages of botanical methods and seven pages of zoological methods, mostly variants of hæmatoxylin methods, but including smears and whole mounts.

Modest though the booklet is, it is well suited to the type of student for whom it is intended. Far too little work is done on permanent preparations by junior students, and this booklet should stimulate improvement in this respect. R. C. MCLEAN.

COPERNICUS AND THE HELIOCENTRIC THEORY

By DR. H. SPENCER JONES, F.R.S.
Astronomer Royal

ON May 24, 1543, died Nicolaus Copernicus. A few days previously, as he lay on his deathbed, the first printed copy of his great work, "De Revolutionibus Orbium Cœlestium", which was destined to become the cornerstone of modern astronomy, was placed in his hands.

Copernicus was born in 1473 at Thorn, on the Vistula, a town which belonged to the Hansa League and which a few years before had come under the suzerainty of Poland. His father was a merchant, who in 1462 had come to Thorn from Cracow, where his grandfather had settled in 1396. His mother, Barbara Wasselrode, came of an old Polish family and was the sister of the Bishop of Ermland. Thus Copernicus was a Slav by ancestry and a Pole by birth. When he was ten years old, his father died and his uncle, the Bishop, took charge of his education. At the age of eighteen, he went to the University of Cracow to study medicine; there he seems first to have become attracted to philosophy, mathematics and astronomy. In 1496 he went to Italy and studied at Padua and Bologna.

At the University of Bologna he came under the influence of Dominico Maria da Novara, an ardent Neo-Platonist, who favoured the Pythagorean doctrines and criticized the Ptolemaic astronomy for its artificial complexity. Copernicus became familiar with the early Greek philosophical and astronomical speculations, which the recent invention of printing was making more readily available. It was probably as the result of Novara's influence that he formed the idea of attempting to construct a different and simpler system of astronomy, founded on the idea that the sun, and not the earth, is the centre of the universe.

In 1505 Copernicus returned to his native country, having been appointed a canon of the Cathedral of Frauenburg. He resided at the episcopal palace of Heilsberg as his uncle's physician until 1512. In that year his uncle died and Copernicus retired to Frauenburg, where the remainder of his life was spent. It was in the quiet years spent at Heilsberg that he put into shape his ideas about a new system of astronomy and prepared the first draft of a work setting forth his system and the arguments for it, and comparing it with observation. This draft was completed about 1514. Copernicus kept the manuscript by him, revising it from time to time and making further comparisons with observations. It would seem that the great work must have been nearly in its final form by about 1529, as no observations of a later date appear in the book. To about this date belongs the MS. "De Hypothesibus Motuum Cœlestium Commentariolus", a short account of his new system, with some of the evidence for it but with none of the calculations, which he prepared for circulation among his friends.

Probably through the circulation of the "Commentariolus", it gradually became widely known that Copernicus held the novel view that the sun and stars were at rest and that the earth revolved round the sun. Luther, in his "Table Talk", called Copernicus a fool for holding such opinions, which were contrary to the Scriptures; but Copernicus ignored these and similar attacks and took no steps to publish his work. The Catholic Church at this time did not raise any objections to the heliocentric system, probably because its implications had not been fully realized. In 1533 a lecture on the ideas of Copernicus was given by one of the Roman astronomers at the request of Pope Clement VII, and in 1536, Cardinal Schonberg wrote to Copernicus for some further information about his theories and urged him to publish his work, as did also his friend Gysius, Bishop of Kulm. At length in 1541 he yielded to the importunities of his friends and particularly of his enthusiastic disciple, Georg Joachim, generally known as Rheticus, who had already published a valuable account of the new system known as the "Narratio Prima", in the form of an open letter to his old master Schoner. Copernicus sent the manuscript of his work to Gysius, who entrusted it to Rheticus to arrange for its printing in Nuremberg. Rheticus, being unable to see it all through the press, obtained the assistance of Schoner and of another friend Osiander, a Lutheran preacher interested in astronomy.

To Osiander was due the insertion, without the knowledge of Copernicus, of an anonymous prefatory note entitled "Ad lectorum de hypothesibus huius operis", which refers to the sun being placed at the centre of the universe as a mere hypothesis, not necessarily true or even probable, made for the purpose of facilitating calculation. Osiander was no doubt unwilling to countenance the reality of the new theory and thought it prudent to disarm prejudice and to overcome religious scruples. But this anonymous prefatory note caused a widespread and mistaken belief in the sixteenth century that Copernicus had advanced his theory merely as a mathematical device and that he did not consider it physically true. Copernicus, however, had expressed his position clearly in his preface, addressed to Pope Paul III, where he explained the reasons which had eventually persuaded him to publish his work. He stated that he regarded a belief in the central position and immobility of the earth as absurd; he attacked without fear the stupidity of those who held such false opinions and scorned those who, without any knowledge of mathematics, distorted passages in the Holy Scriptures.

On the eve of publication of "De Revolutionibus" the system of cosmology most generally accepted, so far as physical theories were concerned, was that of Aristotle. The earth was at the centre of a system of material spheres, to which the planets were rigidly attached. The fixed stars were attached to an outer sphere, the *primum mobile*, which rotated in twenty-four hours; beyond this sphere nothing whatever existed. The planetary spheres rotated in the opposite direction to the sphere of fixed stars, but were dragged along by its superior force. Saturn, the planet nearest to the stellar sphere, required the longest time to complete its revolution, because it had the greatest difficulty in overcoming the force of the stellar sphere; the moon, on the other hand, being nearest to the centre, had the least difficulty and therefore took the least time to complete its revolution. The solid earth was in the centre because the heaviest elements seek the centre; the watery sphere encompassed the earth; the sphere of air came next; and above it, but below the moon, came the fiery sphere, because fire tends to rise above air. The region above the moon was eternal and

unchanging; transitory celestial phenomena, such as meteors and comets, appeared either in the air or in the fiery sphere. Each simple body had one, and only one, simple motion natural to it. There were two simple types of motion, rectilinear and circular. The four elements, earth, air, fire and water, were simple bodies and had rectilinear motion, either downwards, as in the case of earth and water, or upwards, as in the case of air and fire. The sub-lunar regions must therefore be subject to constant change or decay, because these were the products of the conflict of contraries. The heavenly bodies were composed of a fifth simple body, the natural motion of which was circular; as this type of motion had no contrary, the fifth simple body was eternal and not subject to change. If a body had any other movement, it must be caused by an external force; but because a force could not be perpetually applied, a second movement could not be perpetual. The system of homocentric spheres was entirely inadequate to represent the motions of the heavenly bodies; so a complicated system of epicycles and eccentric circles had been merged with it. The Ptolemaic system was accepted as providing the best agreement with observation. But whereas Ptolemy had regarded his system primarily as a mathematical representation, his successors had sought to give physical reality to his deferent and epicyclic circles; they were pictured as the equators of solid crystalline spheres, moving within the annular space between two solid spheres.

What Copernicus achieved was the construction of a complete new system of astronomy, the first since the days of the Alexandrian school. It is against the background of the Aristotelian cosmology that this achievement must be appraised. It is true that Copernicus had precursors among the ancients, as he mentions, who had taught that the earth was in motion. But none of these had done more than to throw out their ideas as mere philosophical speculations. They had not followed them to a logical conclusion, nor developed them into a complete system, which could be made subject to calculation and shown to be capable of explaining the complicated motions of the planets. It is to Copernicus, and to Copernicus alone, that the credit for the heliocentric system is due.

The fundamental idea at the basis of this system is simplicity of explanation of the celestial phenomena. The appearance of the movements of the celestial bodies is the same if the earth turns from west to east as if the heavens turn from east to west. The earth appears to be the centre of the movement; but it is not reason which must decide, it is the simplicity of causes, and it is simpler to suppose one globe to move than hundreds of thousands. Because heavy bodies tended towards the centre of the earth, it was thought that this must be the centre of the universe. But there was no longer any reason to prefer the earth as the centre if all other bodies had gravitation. Copernicus believed that gravitation was a universal force. He said:

"I, at least, am of the opinion that gravity is nothing else than a natural force planted by the divine providence of the Master of the World into its parts, by means of which they, assuming a spherical shape, form a unity and a whole. And it is to be assumed that the impulse is also inherent in the Sun and the Moon and the other planets, and that by the operation of this force they remain in the spherical shape in which they appear."

It is difficult to avoid judging the ideas of former ages by our own, instead of viewing them in comparison with those that went before them. In the time of Copernicus, the physical objections to the earth's rotation were serious. It was believed that if the earth rotated it would fly apart, that objects dropped from a height would fall far to the west, that anything not fixed to the earth would be torn from it and that clouds would always move towards the west. It was not until Galileo conceived the principles of elementary mechanics that such objections could be properly refuted. Copernicus possibly suspected that all was not well with the current ideas about mechanics; he countered the objections to the hypothesis of the rotation of the earth with the retort, "What holds together the rotating heavens in the Ptolemaic theory?"

With regard to the revolution of the earth about the sun, Copernicus argued as follows:

"If then the Earth possesses other motions besides that around its centre, then they must be of such a character as to become apparent in many ways and in appropriate manners; and amongst such possible effects we recognise the yearly revolution. If one admits the motionlessness of the Sun, and transfers the annual revolution from the Sun to the Earth, there would result, in the same manner as actually observed, the rising and setting of the constellations and the fixed stars, by means of which they become morning and evening stars; and it will thus become apparent that also the stations and the retrogradations of the planets are not motions of these but of the Earth, which lends them the appearance of being actual planetary motions. Finally, one will be convinced that the Sun itself occupies the centre of the universe."

The Copernican system not only provided a simple explanation of the stationary points and retrograde motions of the planets but also, and for the first time, enabled the dimensions of the orbits of the planets to be determined in terms of the distance of the earth from the sun. The relative distances found by Copernicus were nearly correct. This was a great advance; the epicyclic system could give no information whatever about the actual distances of the planets but merely, for each planet, the ratio of the radii of the deferent and epicycle. The Arabian astronomers had assumed that the greatest distance of any planet was equal to the least distance of the one next above it and that the sphere of the fixed stars was at a distance equal to the greatest distance of Saturn. But inasmuch as Copernicus accepted the erroneous value of 3′ for the solar parallax, found by Hipparchus, the dimensions, in miles, of the solar system that he obtained were only about one twentieth of the true values.

To Copernicus, as to his contemporaries and also to the Greeks, the simplest form of revolution of one body about another was a motion as if the two bodies were rigidly connected. In order that the earth's axis should have a fixed direction in space, he therefore had to assume a motion of the axis around a cone, in a period of a year. But in order to account for the precession of the equinoxes, which he determined as 50·2″ annually—a value that is very close to the true value—he supposed that the motion was completed in slightly less than a year. The net effect was to give the earth's axis a slow conical motion in space, with a period of 26,000 years. Precession had been recognized by Hipparchus as a motion of the celestial equator, such that its inclination to the ecliptic remained unchanged;

but so long as the earth was supposed to be at rest at the centre of the universe, it was not possible to relate precession in any way to the earth's axis.

Copernicus took over from the Arabian astronomers the imaginary phenomenon of trepidation—a supposed oscillation of the equinoxes backwards and forwards, which caused the value of the precession to fluctuate; associated with it was a spurious variation in the obliquity of the ecliptic. To account for trepidation, Copernicus assigned two librations to the earth's axis. Thus, in his system, the earth had movements of rotation and of revolution, together with a combined progressive and wobbling motion of its axis. To those imbued with the Aristotelian conception that the heavenly bodies could have only circular motion, the gratuitous introduction of three motions was a serious objection to the Copernican system.

By placing the sun at the centre and assuming the diurnal rotation and annual revolution of the earth, Copernicus had brought about a great change in outlook, but when he came to the detailed representation of the motions of the bodies in the solar system, he had to revert to the Ptolemaic system of eccentric and epicyclic circles. Chapter IV of Book I of "De Revolutionibus" is entitled: "That the motions of the Heavenly Bodies are Uniform, Circular, Uninterrupted or are made up of Combined Circular Motions". The number of circles was reduced from about eighty to thirty-four, so a considerable simplification in detail, though not in method, was brought about. But no other course was open to Copernicus. The accurate observations of Tycho Brahe (1546–1601), from which by laborious calculations Kepler (1571–1630) was to prove that the orbits of the planets are ellipses, were yet to be made. Copernicus did succeed in improving appreciably the elements of the planetary orbits. The tables constructed by Erasmus Reinhold on the basis of the calculations of Copernicus, published in 1551 and known as the "Prutenic Tables", were decidedly superior to their predecessors, the "Alphonsine Tables" (published in 1272), and were used for calculating the places of the celestial bodies until superseded by the "Rudolphine Tables" of Kepler (published in 1627). The Prutenic Tables, though they provided no sort of justification for the Copernican system, undoubtedly did much to induce astronomers to recognize its merits.

In the Ptolemaic system, the sphere of fixed stars was located just beyond the sphere of Saturn. But in the Copernican system a vast space was left between Saturn and the stars. Copernicus recognized that if the stars were near they would show an appreciable annual parallax, resulting from the motion of the earth round the sun. As no parallax had been detected, the stars must be at a great distance. The instruments of the time might have just detected a parallax of 5′, which would require the stars to be at least seven hundred times as far from the earth as the sun is. This enlargement of the universe was, of course, a change of degree rather than of kind. The objections to it in the time of Copernicus were scientific rather than philosophical. At that time, the angular diameters of the stars were very much over-estimated. Tycho Brahe assumed smaller apparent diameters than did any other astronomers before the invention of the telescope. He assigned a diameter of 2′ to a first magnitude star. But in the time of Copernicus a diameter of 5′ would have been considered reasonable. Such an angular diameter would require the actual diameter of the star to be not less than the distance of the earth from the sun. The opponents of the Copernican system could contend with some reason that it was less credible that the stars could be of such vast dimensions than that the sphere of stars was in rotation, and that Copernicus had made an entirely unjustifiable assumption that the stars were at a very great distance merely to obviate the serious difficulty that the stars showed no annual parallax. This was one of the main reasons that caused Tycho Brahe to reject the Copernican system and to substitute in its place a geocentric system, in which the sun revolved round the earth but all the other planets revolved round the sun; mathematically, the Tychonic system was identical with the Copernican system.

Though in "De Revolutionibus" Copernicus represented the stars as being on a sphere and all at the same distance from the earth, he recognized that the stars, being assumed at rest, might well be scattered throughout an infinite universe. But this could not be tested in his day by observation, and he declined to commit himself on the question. In Book I, Chapter VIII, he says:

"For the chief reason that has moved some to think the Heavens limited was motion, which they thought without controversy to be indeed in it. But whether the world have his bounds or be indeed infinite and without bounds, let us leave that to be discussed of philosophers."

It was Thomas Digges (1546–1595), the English mathematician and astronomer, who first broke definitely with the older cosmologies which had assumed the stars all to be at the same distance. In his "Perfit Description of the Caelestiall Orbes", first published in 1576, an English translation was given of the principal chapters of Book I of "De Revolutionibus", with some paragraphs explaining his own ideas, of which the following is an extract:

"We may easily consider what litle portion of gods frame, our Elementare corruptible worlde is, but neuer sufficiently be able to admire the immensity of the Rest. Especially of that fixed Orbe garnished with lightes innumerable and reachinge vp in *Sphaericall altitude* without ende. Of whiche lightes Celestiall it is to bee thoughte that we onely behoulde sutch as are in the inferioure partes of the same Orbe, and as they are hygher, so seeme they of lesse and leaser quantity, euen tyll our sighte beinge not able farder to reache or conceyue, the greatest part rest by reason of their wonderfull distance inuisible to us."

The reputation of Thomas Digges as a man of science, his advocacy of the Copernican system, the popularity of the "Perfit Description", which went through many editions, whereby an account of the Copernican system was made available to those who could not read Latin, did much to bring about its earlier acceptance in England than on the Continent.

Though Tycho Brahe, as we have seen, did not accept the Copernican system, yet the observations of this most assiduous and systematic observer of the heavens before the days of the telescope did much to help it forward. In 1572 a bright new star appeared, of which he obtained a long series of observations. His discussion of these established that the star was not a comet, as many had thought, and that it was more distant than Saturn. His observations of the great comet of 1577 proved that it was far more distant than the moon and therefore not in

the sphere of fire where, according to Aristotle, comets were situated. Thus the region beyond the moon was not, as Aristotle had supposed, eternal and unchanging. By giving so severe a blow to the Aristotelian theories, Tycho Brahe helped to remove one of the chief obstacles to the progress of the Copernican theories.

The first attempt at a physical explanation of the rotation of the earth was due to William Gilbert who, in his "De Magnete", published in 1600, ascribed it to the magnetic properties of the earth. Gilbert found that his terella or magnetized sphere rotated under the influence of a magnetic field. Though Gilbert's theory was not correct, by providing a plausible explanation of the rotation, it removed an objection to the Copernican system and it was accepted by Kepler and Galileo as a tentative hypothesis.

In 1609 Kepler published his book "De Motibus stellæ Martis", announcing his discovery and proof of the elliptical orbit of Mars, which was destined to cause the final disappearance of eccentric and epicyclic circles. This remarkable discovery would not have been possible if Kepler had not accepted the heliocentric theory. In the same year Galileo constructed his first telescope. In 1610 his discovery of the satellites of Jupiter was announced in the "Sidereus Nuncius"; in 1611 he discovered sunspots, which he announced in 1612 in the "Discorso" and more fully in 1613 in the "Istoria e dimostrazioni"; he also observed the phases of Venus and Mercury. These observations of Galileo made it seem probable by analogy that the earth rotated on its axis and that, with the other planets, it revolved about the sun.

When the attack on Galileo was made by the Catholic Church, the "De Revolutionibus" was placed on the papal "Index" in 1616 and declared heretical. The book was only allowed to be read provided all passages referring to the motion of the earth were altered to assert that this idea, though false, was introduced merely as a mathematical hypothesis to simplify the calculations. The Tychonic system, unlike the old Ptolemaic system, could be reconciled with these new discoveries, and it therefore remained as the only serious competitor to the Copernican system, though it was generally modified to admit of the rotation of the earth. Nevertheless, by the end of the seventeenth century, the Copernican system had finally displaced the Tychonic system. This was not because direct observation had provided any confirmation of the Copernican system, but because the heliocentric system was better adapted to the physical and mechanical explanation of the planetary motions. It fitted in naturally with Newton's mathematical demonstration of Kepler's laws of planetary motion in terms of universal gravitation. Observational proof of the revolution of the earth round the sun was eventually provided by Bradley's discovery of aberration, announced in the *Philosophical Transactions* in 1729; the first definite detections of the parallax of a fixed star came long afterwards and were announced almost simultaneously by Bessel in 1838, by Henderson in 1839 and by Struve in 1840. But the Copernican system had become firmly established and universally accepted long before these observations had proved its truth. With its acceptance, the conception of a small geocentric universe had finally to be abandoned, and a profound revolution in human thought and outlook had been accomplished.

THE WORK OF COPERNICUS

AT the meeting of the Royal Astronomical Society, held at Burlington House on May 14, Prof. Herbert Dingle gave an address on Copernicus, which supplements in some respects the article by Dr. Spencer Jones printed above. It is not generally known that Copernicus attained some proficiency in languages and even published a translation from Greek into Latin of the poems of Theophylactus Simocatta. He possessed some artistic skill, and the famous clock tower of the cathedral at Strasbourg contains a copy by other hands of his self-portrait.

In spite of his attainments, more especially in the realm of astronomy, Copernicus had a natural humility which led him to shun publicity both for himself and his work, and he was even prepared to depreciate his own worth in comparison with that of others. His dread of derision, not the fear of persecution, was largely responsible for the delay in the publication of his great work, "De Revolutionibus Orbium Coelestium". There is no evidence that he concealed his thoughts because he dreaded persecution—a popular belief which probably emanated from the fact that his work was not published until the end of his life. Many years before this, his views were well known wherever astronomy was studied because he had circulated (in manuscript form) a summary account of his astronomical system. Although this was limited to those capable of judging, his reputation was established, and ten years before his death the papal secretary delivered a lecture on his system to the Pope and his Court. No question of persecution arose as a result of promulgating his views, and he was obviously held in high esteem even in middle life, because so early as 1514 he received an invitation from the Lateran Council in Rome to assist in the reformation fo the calendar. His grounds for refusal are interesting; he held that such a reformation could not be carried out adequately owing to the incomplete knowledge of the motions of the sun and moon.

It must not be assumed that because there was no fear of persecution Copernicus was not subjected to ridicule. Luther poured contempt on his system and even predicted that he would overturn the whole science of astronomy—a prediction which was literally fulfilled, but not in the sense intended by Luther. Twelve years before his death he had been satirized on the stage at a place near Frauenberg, and this and various misunderstandings of his views were very painful to his sensitive nature. In the dedicatory letter to the Pope, prefaced to "De Revolutionibus", he admits that misunderstanding had been responsible for preventing him from publishing his views previously.

It is sometimes assumed that Copernicus' work is of a very controversial nature, but it is not primarily polemical; it is a complete treatise on astronomy in which the centre of the earth is discarded in favour of the centre of the sun as the stationary point of the universe. The arguments in favour of this new view occupy a relatively small portion of the work, and the greater part is concerned with descriptions of the movements of the celestial circles, with mathematical theorems, and with astronomical tables which were intended to supersede the earlier collection. While his tables were an improvement on the older tables, they soon became obsolete under the observational work of Tycho Brahe, and in the light of present-day knowledge the accomplishments of

Copernicus seem very small. He merely assigned the diurnal motion to the rotation of the earth, and the annual motion to its revolution round the sun, and from these postulates he worked out the astronomical consequences by means of the old devices of eccentricities and epicycles. A certain amount of simplification was introduced into the Ptolemaic scheme by reducing the necessary number of circles from about eighty to thirty-four, and in addition, credit is due to Copernicus for improving the elements of the planetary orbits. It is difficult for us now to understand why such a book—far from objectionable on religious grounds—should have been declared heretical sixty-three years after the death of Copernicus and placed on the Papal Index, from which it was not removed until 1835. The reasons for this step are interesting in view of the fact that the Church at first offered no opposition to the views of Copernicus.

When the stars were believed to move round the earth the universe could not be considered infinite; such a conception would imply that some stars were moving with infinite velocity to complete their diurnal course. When Copernicus transferred the diurnal motion to the earth there was no fundamental objection to infinite space, and this challenged the existing philosophy of Christianity. The Church held that there could not be an infinite material universe, with no abode of the blessed beyond the outermost sphere, and hence the views of Copernicus were a potential source of heresy. Even in the days of Bruno the discoveries of Copernicus were unhinging men's minds, and this little world was regarded in a new light. The new learning was easily used as a lever to displace the antiquated system which had come down from Aristotle.

It is not easy to decide definitely about the view of Copernicus himself on these matters, or to discover whether he considered his system a real account of the universe or merely a calculating device. Arguments can be adduced in favour of either opinion, but, as Prof. Dingle pointed out, at the time of the next centenary of "De Revolutionibus", it will be difficult if not impossible to understand what all the controversy was about. The question is: "Is a scientific explanation of a phenomena the real truth?" Assuming that two different mathematical descriptions of a physical situation are equally consistent with the facts, which is the true one? A definite general answer has been given in the present century, and that is that the aim of science is to save the phenomena, in other words, to find a rational connexion between the observations. When this is done, the word 'real' or 'true' is a meaningless label, and of the two descriptions assumed we may adopt whichever we wish.

In the days of Copernicus this answer had not been formulated, though its validity was admitted in very obvious cases. Whatever may have been his own view of his work, we see it now as one of the greatest landmarks in scientific history, and without it the work of Kepler and Newton, and hence of modern dynamical astronomy, would have been impossible.

Many find it difficult to understand how an original thinker like Copernicus could accept the metaphysical principles which seem so baseless to-day. In answer, it may be pointed out that consistency is not a *sine qua non* of greatness, for if it were, the first great man has yet to be born. Millions at present believe that three independent persons are yet one God, but many of these allege that physics is talking nonsense when it suggests that a wave and a particle are yet one electron. Copernicus has one outstanding distinction, even if he was unable to free himself completely from illusions. In an age when even the greatest were unable to escape from astrological speculations, he alone transcended them altogether. He undertook the complete reform of astronomy, the erasure of the product of two thousand years of toil, and a rebuilding of the whole edifice, and he takes his place among the great original thinkers of history.

CO-ENZYMATIC REACTIONS

By PROF. J. K. PARNAS
Member of the Academy of Sciences of the U.S.S.R.

THE development of biochemistry, during the last two decades, has largely increased the number of known components of organisms, and beyond discovering them and surveying their distribution, biochemistry was able to assign to many formerly known and newly discovered substances their part in the structure of living matter, their part in the chemical reactions occurring in cells and tissues, and in the regulation of the functions of the organs. The large increase of our materia biochemica was proceeding simultaneously with the elucidation of the mechanisms of biochemical reactions, which appear, now, quite different from what could be imagined twenty years ago; not only in the complexity of the intermediary transformations leading to the final products, but especially as concerns the nature and the numbers of reagents—of the organism's own reagents, of course—taking part in them.

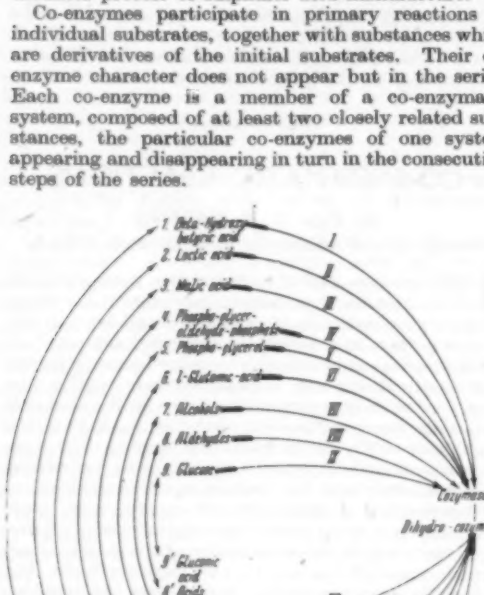
Many chemical transformations which take place during the metabolism in cells and tissues have been resolved, indeed, into series of intermediary reactions, linked together in such a way that the products of earlier reactions are transformed in later ones: the final balance of the series gives the equation of the transformation of initial substrates into final products. Of the products of intermediary reactions, some become substrates of the reactions which follow, others appear as final products in the balance. Such intermediary reactions which cannot be resolved into series of two or more may be claimed to be primary reactions: this claim is not, however, a conclusive one, because further research may reveal as a balance of a complicated series even such reactions which at present do appear simple enough to be primary ones. The investigation of enzymatic reactions with pure isolated enzymes and co-enzymes may be considered at this moment to be the most promising tool for resolving balances of biochemical series into primary reactions.

The ideas concerning co-enzymes and co-enzymatic reactions are given here in short. They represent the views of the present author, and are entirely different from the views held by O. Warburg and by H. von Euler, and others[1].

The primary reactions are sometimes much more complicated than final balances. This is so, because not only initial substrates are transformed in them, and such intermediary substrates which are derivations of the initial, but also substances which are not related to the initial substrates, and which do not appear in the final balance, because after disappear-

ing in some intermediary reactions they are regenerated out of their transformation products in some later ones. Such substances are called co-enzymes: they are partners of some primary bimolecular enzymatic reactions, and their role may be compared with the role of nitric acid in the lead-chamber process of sulphuric acid manufacture.

Co-enzymes participate in primary reactions as individual substrates, together with substances which are derivatives of the initial substrates. Their co-enzyme character does not appear but in the series. Each co-enzyme is a member of a co-enzymatic system, composed of at least two closely related substances, the particular co-enzymes of one system appearing and disappearing in turn in the consecutive steps of the series.



The following are the well-known co-enzyme systems of cellular and tissue metabolism:

(1) *Cozymase*[2] and *dihydro-cozymase* concerned with electron and proton transfer (from initial and intermediary substrates) in very many anærobic and ærobic reactions. (2) *Phospho-cozymase*[3] and *dihydro-phosphocozymase*, taking part in not so many electron transfers, so far as is known. (3) *Adenosine-monophosphoric, adenosine-diphosphoric, adenosine-triphosphoric* acid, concerned with transphosphorylations in animal tissues. (4) as (3), but including *adenosine*, concerned with transphosphorylations in yeast. (5) *Ornithin-citrulin-arginine*, concerned with urea formation and transamidination. (6) α-keto-glutaric acid-*l* glutamic acid, concerned with transaminations. (7) Riboflavine-adenine-dinucleotide, dihydro-riboflavine-adenine-dinucleotide, concerned with certain steps of electron and hydrogen transfer. (8) Thiamin diphosphate, concerned with anærobic and ærobic decarboxylations. (9) Succinic acid-fumaric acid, as (7). (10) Malic acid-oxaloacetic acid, as (7) and (9).

Co-enzymes react as well as substrates inside the reactive complex, which they form with the enzyme and its activators, according to the general principles of enzymatic kinetics. Two kinds of co-operation between enzyme and co-enzyme are known.

(1) Both substrate and co-enzyme are linked to the enzyme during the reaction, but after the transfer of electrons, atoms or groups from or to the co-enzyme, both newly formed derivatives part from the enzyme. The co-enzyme, afterwards, is regenerated out of its product in another enzymatic act, in which it reacts with another enzyme and another substrate. This is the case with co-enzymes 1–6, probably also with 9 and 10.

(2) The co-enzyme remains attached to the enzyme, and it oscillates, for example, between its hydrogenated and dehydrogenated form—without parting from its enzyme. The two forms—say, K' and K''—react in co-operation with the same enzyme, in turn with two substrates, and are regenerated to the previous state in the second reaction. This is the case with flavine co-enzymes: the complexes (co-enzyme-enzyme) have every likeness to the enzymes with fixed prosthetic group.

We may call the first group of co-enzymatic systems polyenzymatic or mobile, the second monoenzymatic or fixed co-enzymes. The oxido-reductions, as occurring, for example, in the liver, where *beta*-oxybutyric acid; lactic acid, malic acid; phosphoglycerol; phosphoglyceraldehydephosphate; glutamic acid; glucose; aldehydes; alcohols are reversibly dehydrogenated by specific enzymes and cozymase and with formation of dihydrocozymase to aceto-acetic acid; pyruvic acid; oxaloacetic acid; phosphodioxyacetone, phosphoglyceric phosphate; keto-glutaric acid; gluconic acid; acids: aldehydes respectively are an example of a group of co-enzyme linked reactions.

In such groups of co-enzyme linked reactions—as may be seen in the diagram—the hydrogen transported by a specific enzyme from any one of the donors to the co-enzyme may pass from the dihydro-co-enzyme to any one of the dehydrogenation products, acting as acceptors. What happens depends, of course, on the affinities and conditions, but the ways are made practicable and the activation barriers can be overcome.

The analysis of a biochemical reaction will not be completed until even the ultimate reactions between the enzymes themselves and the substrates of the primary reactions are elucidated. This is a matter for future research. For the present we are concerned with such primary reactions including the transformations of substrates and co-enzymes the stoichiometric equations of which can be formulated. But as the co-enzymes belong to the catalytic systems, their transformations disappear in turn; and it may be useful to introduce another unity of transformations of metabolites, in which the co-enzymes do not appear. We shall consider, in the present article, such balances of smallest sets of co-enzyme-linked primary reactions from which the transformations of the co-enzymes taking part in these reactions disappear: we shall call them minimum balances.

The minimum balances correspond to what could be considered as primary reactions of intermediary substrates, before the co-enzymes and their participation in the metabolic reactions were known.

It is interesting to consider the catalytic possibilities in co-enzyme-linked enzyme groups. Take a co-enzyme-linked group with n hydrogenated (Red.) and n dehydrogenated (Ox.) partners, where every Ox.

corresponds to some one of the Red., and vice versa; and with n specific enzymes to meet. How many minimum balances can be brought about by such a system? The number of reversible minimum balances in such group (m) is given by the equation $m = \frac{n(n-1)}{2}$. One minimum balance is possible when $n = 2$, three when $n = 3$, six when $n = 4$, ten when $n = 5$, and so on.

Should the reactions between the n Red. and n Ox. be catalysed directly by non-co-enzymatic enzymes and not co-enzyme-linked balances, then $\frac{n(n-1)}{2}$ enzymes would be required, namely, as many as there are reactions possible. This gives one enzyme for a set of $n = 2$, which is less than required for a co-enzymatic transfer; three enzymes for $n = 3$, which is the same as for co-enzymatic transfer; but for groups larger than 3 the number of enzymes required for non-co-enzymatic transfers becomes greater, and much greater than for co-enzymatic transfers, increasing just as the number of possible reactions between the n Red. and n Ox.

If the transfer goes on irreversibly between n donors and m acceptors, the acceptors being not directly related to the donors, the number of possible reactions and of enzymes needed for direct transfer is $(m \times n)$; when there is an intermediary co-enzyme system in common, then the number of enzymes needed is $(n + m)$.

Taking a more general example: for direct transfer by enzyme action of electrons or groups from n donors to n acceptors, none of the latter being a derivative of some one of the donors, n^2 reactions are possible, and such a number of enzymes would be required should the enzymes be specific. Should the transfer, however, proceed through one common co-enzyme system, that is, the group transferred pass first to the co-enzyme K', changing it to K''; and then from K'' to the several acceptors; then only $2n$ enzymes are needed, that is, n for the transfer from n donors to K', and n for the transfer from K'' to the n acceptors.

As stated above, in groups of co-enzyme-linked reactions larger than 3, every enzyme participates at more than one minimum balance. The number of minimum balances in excess of one for one enzyme is, of course: $S = \frac{n-3}{2}$.

To n = 2, 3, 4, 5, 6 .....10 corresponds

s = −0·5, 0; 0·5, 1, 1·5 .... 3·5

m = 1, 3, 6, 10, 15 45

Large groups of co-enzyme-linked reactions are known to occur in muscle, liver, yeast, the cozymase system being the link; smaller groups for phospho-cozymase, and for the adenosine-polyphosphoric acids. The largest known is probably the group of amino-pherases, linked by glutamic or aspartic acid in animal and plant tissues respectively. These amino-pherases are not yet resolved into individual specific enzymes corresponding to individual monocarboxylic l-amino-acids each. But take, for example, the case of ten amino-acids exchanging amino-groups. Should there be specific aminopherases for direct exchange between ten amino-monocarboxylic acids and ten α-keto-monocarboxylic acids, the latter not being derivatives of the first, then 100 such enzymes would be required, while only twenty are required for aminopheresis through the intermediary of the co-enzymatic systems of monoamino-dicarboxylic acid.

It makes no difference to the role of co-enzymes in co-enzyme-linked groups, whether they are mobile or enzyme-fixed: but the fixed co-enzymes are essentially monoenzymatic in their physiological function. Of course, flavine-adenine-dinucleotide is involved in a certain number of different transformations: in the oxidation of dihydrocozymases, in the oxidative removal of *d*-amino-acids, and in oxidation of xanthine; and dihydro-flavine-adenine-dinucleotide does participate in hydrogenation of fumaric acid too. These reactions are not, however, reversible ones: the first brings the hydrogen of substrates into the final path of oxidation, the second participates in the stereochemical rearrangement of amino-acids not by returning electrons and protons to the ketoacids, but passing them to the oxidation path. The fixed co-enzymes are not physiologically polyenzymatic, and this is characteristic for the very pathway of oxidations in which they participate. The poly-enzymatic function of mobile co-enzymes is most important for fermentations and for the anaerobic part of the aerobic reactions.

It is interesting to consider the specificity of co-enzymatic reactions. Take the case in which the enzymes of co-enzymatic reactions are strictly specific, as it occurs with the hydrogenopherases of the cozymase-linked group; it is well known that the lactic hydrogenopherase, isolated by Straub in pure crystalline form, does not act on malic acid and cozymase. In a system containing lactic acid, hydrogen from lactic acid goes to oxaloacetic acid: this is the principle of co-enzyme-linked reactions. In larger groups of co-enzyme-linked reactions the substrate-specificity of the enzymes in co-enzyme-linked groups places them as to the degree of specificity in a position intermediate between the exclusively substrate-specific enzymes and the enzymes possessing group-specificity. The specificity of enzyme actions *sensu strictiori* does concern primary reactions; it holds good for minimum balances in sets of two and three co-enzyme-linked groups; it fades away in larger groups.

It is interesting, also, to consider the way in which co-enzyme-linked groups of enzymatic reactions may be linked one with the other. Three reactions are known to occur in the liver in which the co-enzyme may be either cozymase, or phospho-cozymase, namely, the oxidation of glucose of *l*-glutamic acid. This means that the electrons of these substances may pass either to the acceptors of the cozymase-linked group or to the acceptors of the phosphocozymase-linked group; and the entire mobile systems of the co-enzyme-linked groups of similar reactions do become linked through common substrates. The number of sets of two reactions from which the co-enzyme system disappears equals the product of such minimum balances of the two groups, when the substrate in common is taken into account for each of both groups; but minimum sets involving both co-enzyme systems must contain not less than four reactions.

The meaning of the parcelling even of the elementary metabolic act of combustion of 2H into many consecutive steps was most clearly explained by Szent Györgyi; the meaning of the intermediaries in metabolic transformations, by the comparison with waterways and sluices in them, was aptly explained

by H. Borsook. In the present article I have tried to bring into prominence a feature of co-enzymatic reactions, which has not, so far as I know, been noticed until now. It is the role of polyenzymatic co-enzymes in bringing electrons, atoms or groups into one collector, and distributing them further in an exergonic way, to organic acceptors, in fermentations and in the anaerobic part of aerobiosis, or to fixed co-enzymes of the pathway of oxidation, in the aerobic part. They are a part of the catalytic apparatus of organisms which contribute to such a co-operation of specific enzymes by which these enzymes, without losing their specificity in the primary reactions they catalyse, are able to perform each more than one transformation of the metabolites.

[1] For a more comprehensive review, see Parnas, J. K., Glykogenolyse, Hdb. d. Enzymologie (Nord u. Weidenhagen, **2**, 902–967, Leipzig 1940, or Ouspechi Sovrem. Biologii, U.S.S.R., **12**, 393, 1940), also the article by W. Franke in the same volume. Also: D. E. Green. "The Mechanisms of Biological Oxidations", London, 1941.

[2] Synonymous with what is called by different authors 'co-enzyme I' and 'co-enzyme II', or 'codehydrase I and codehydrase II', or 'pyridine' or 'pyridine-nucleotide'. Cozymase was discovered by Harden and Young, given this name, and investigated, under the same, in numerous papers by von Euler and Myrbäck. There is no reason for giving a substance a new trivial name after the isolation and elucidation of its structure. Phospho-cozymase is a logical extension of the name cozymase for its derivative containing one phosphate group more.

BOTANY IN INDIA

By SIR GEOFFREY EVANS, C.I.E.

AT the thirtieth Indian Science Congress held in Calcutta early this year, the Section of Botany was presided over by Dr. Kalipada Biswas, director of the Royal Botanic Garden, Calcutta. In his presidential address, which is entitled "Systematic and Taxonomic Studies on the Flora of India and Burma", Biswas dealt very fully with many aspects and covered such a wide range of subjects that it is obviously impossible, in the limited space available, to attempt more than a general summary.

In the opening stages of his address, an account is given of the history of systematic and taxonomic researches in India. The investigations, on lines followed by Western countries, can be divided into three main periods. The first period was from 1768 until 1848 and started with the pioneer work of Koenig, who was the first to introduce the Linnean system into India. Great encouragement to the work was caused by the foundation of the Royal Botanic Garden at Sibpur, Calcutta, in 1787, by Colonel Robert Kyd, who was honorary superintendent of what was then the East India Company's Garden, and it was after Roxburgh had succeeded Kyd on the latter's death that botanical researches on a proper basis may be said to have become properly established in India. The manuscripts of "Flora Indica" and "Hortus Bengalensis" were completed by him between 1794 and 1813, and he was rightly known as the Father of Indian Botany.

The second period begins about 1846 with the first visit of Sir Joseph Hooker. This was a great period for botanical exploration and collection, and is full of the names of many famous botanists who made valuable contributions to both systematics and the enhancement of the plant collections in the Sibpur Herbarium, and also to the interchange of specimens with Kew and other famous herbaria.

Full tribute is paid to the long list of illustrious names of famous botanists who have in turn ruled over the destinies of the Royal Botanic Garden in Calcutta and done so much to foster botanical research. Biswas points out how, until quite recently, nearly all the original work has been carried out by Europeans and that only about 30 per cent of work published has been contributed by Indians. He asserts that very few members of the staff of Indian universities take any interest in systematic and taxonomic studies, preferring to devote their attention to those other branches of botanical research that can be carried out in laboratories, rather than the undertaking of prolonged field work and subsequent determinations of the plants collected. One of the results is that Indian workers on systematics are now mainly confined to Government institutions in Calcutta or at Dehra Dun, which is the headquarters of the Forest Service.

This lack of trained botanists is to be deplored in view of the wide field that awaits investigation, a point that is clearly brought out by a map showing the large areas that are unexplored or only partially explored from the botanical point of view. In many areas the larger flowering plants have been well worked over, but it is particularly the smaller and more primitive forms of plant life that now need attention. The Indian Botanical Departments have hitherto surveyed mainly the higher forms of plant life; but the primitive forms have an equally important significance to the plant geographer and the general botanist. Dr. Biswas touches on this latter point in his section dealing with mangrove swamps, which he divides into regions according to species and to their algal associations, which are said to be characteristic.

In the main body of his address he deals with the vegetation of the rain forest regions of Eastern India and Burma, enumerating the chief species that constitute the various strata in forest of this type. Later on he deals with the effect of altitude on plant growth and the characteristic species of the eastern Himalayas. He suggests that the Abor country of northern Assam might prove to be particularly suitable for the study of questions concerning the ecology and geographical distribution of plants.

A considerable portion of the address is occupied in a discussion of the different elements that comprise the Indian flora. He quotes Dr. Chatterjee's estimate that more than 61 per cent of the plants are endemic, and gives his own figure for the Sikkim Himalaya in the Darjeeling district alone as 50 per cent indigenous to the Himalaya, the rest being foreign species from other parts of Asia, America and Europe and a few from Australia. Many of these have no doubt been introduced either deliberately in cultivation or accidentally by trade routes, within comparatively recent times.

Dr. Biswas discusses the modern trend of systematic and taxonomical studies and traces the history of botanical study, stating that it received the attention of the Hindus more than 2,500 years ago. Plants were used by the ancient Rishis and sages in India in connexion with various rituals. Later on, plants were studied in relation to agriculture and horticulture, and medicinal plants receive particular attention in the Ayurveda. He thinks it not unlikely that the knowledge of plants spread gradually from Hindustan to Europe via Arabia, Syria and Greece. There is little doubt that botanical knowledge in Europe advanced through the herbalists. For example,

d'Alechamps recognized eighteen classes of plants according to their medicinal properties. As knowledge increased, the classification of plants took its proper form in the hands of De Candolle and Linnæus, and as a result of their work it has now reached its present high standard. It is still a matter of dispute as to the perfect system of classification and the best method of describing the plant. The idea, held until comparatively recently, that systematics consisted of a specialized and rather narrow branch of biology, empirical in character and without general application to other branches of science, is now recognized as out of date. Recent investigations of workers devoting their attention to morphology, ecology, anatomy, genetics, cytology and plant breeding can now be utilized correctly to stabilize the systematic position of a particular plant. In other words modern thought tends to the opinion that systematics must now be studied in relation to general biology.

As has already been mentioned, Dr. Biswas has covered a very wide field dealing with many different aspects. Possibly it would have been better if he had confined his discussions to a more limited field so as to bring home to the public his main point, which is the special need for more botanical research. No one can cavil at his plea for more development in this direction. India now has her destiny in her own hands. In the past most of the systematic work in botany was carried out by Europeans who have well and truly pointed the way, but now the "mantle of Elijah" has fallen on Dr. Biswas and his associates, and they are naturally anxious that progress should not be delayed.

The scope for systematic botany in India, as he has pointed out, is enormous. Many unknown or little-known plants await discovery, and many of them are doubtless of commercial, medicinal or agricultural importance. The part that systematic botany may well play in the economic side of development has been mentioned in the address, but might well have been reviewed even more fully as it plays an important part in deciding the actions of Governments. It has also proved its value during the present War when so many new products and so many substitutes have had to be found to cope with war-time shortages and demands. Let us hope that botany, and in particular systematics, will take a more leading part in the life of the Indian universities than apparently has been the case in the past, and also that private citizens may be found who will undertake work of this kind as a matter of choice. In Great Britain much work has been carried out by individuals in a private capacity. It has supplemented the organized work of the universities and the scientific departments of State, and has resulted in valuable accumulations of our knowledge of plants. This is a line of work that might with advantage be followed in India in the future.

OBITUARIES

Prof. Warrington Yorke, F.R.S.

As proof that any man of science enjoys fame extending beyond the limits of his own country, we have at our disposal one rather delicate test. The printed word has, of course, great value in this respect, and there is no doubt that publication of papers by foreign journals denotes a quite definite recognition of a man's status by his colleagues abroad. But it is when members of learned societies in other countries have become so interested in a man's work that they desire to see him in person, and hear him for themselves, that it may most truly be said that he has achieved an international reputation in his subject.

Warrington Yorke had attained that degree of eminence. This is evident from the number of his lecture engagements abroad, of which the following may be mentioned. In the year 1933 he lectured on chemotherapy to the members of the Medical Academy in Düsseldorf; in 1934, at the International Malaria Congress in Rome, he read a paper entitled "A Contribution to the Biological Side of Chemotherapy"; in 1939, at the Third International Congress for Microbiology in New York, he gave an address on "Recent Work on the Chemotherapy of Protozoal Infections". During the same period he was also greatly in demand as a lecturer at home. He addressed the Medical Society for the Study of Venereal Disease on "Drug Resistance" in 1933, the Royal Society of Tropical Medicine and Hygiene on "Chemotherapy in Protozoal Infections" in the same year, and also in 1935; the Chemical Society of Liverpool on "Chemotherapy" in 1940, and the Biochemical Society of London on the "Diamidines" in 1941.

A perusal of the above titles might lead the reader to suppose that Yorke had always specialized in the application of drugs to the treatment of disease, and certainly the high standing which he enjoyed as an exponent of chemotherapy would justify this supposition. But in fact his enthusiasm for this subject was a comparatively late development. It originated when, in 1929, he discovered a method by which the pathogenic trypanosomes which affect man and animals could be kept alive outside the animal body. This discovery placed in his hands a ready means by which he could study the effects of drugs on some of those protozoal parasites which cause disease in man. The fact that parasites treated with doses of certain drugs, insufficient to kill them, might develop a remarkable resistance against the effects of further and larger doses of the same drugs, was of fundamental importance in the drug therapy of such diseases as sleeping sickness. Of even greater biological significance, and of no less practical importance, was the discovery that such drug resistance, once acquired by the parasite, might persist even while the parasite was passing through its curious development in the vector. For example, an arsenic-fast strain of trypanosome would still possess its acquired arsenic-fast character even after the trypanosomes had completed their cycle in the body of the tsetse fly. But the discovery of the technical device mentioned would never in itself have enabled a man to advance his subject in such a notable manner as Yorke succeeded in doing. It was on account of the great knowledge and wide experience of tropical diseases he possessed, which he had acquired during many foregoing years of arduous work, that he found himself in a position to take the fullest advantage of this discovery.

Warrington Yorke was the son of the late Rev. H. Lefroy Yorke, and was born at Lancaster in 1883. He attended University School, Southport, and Epworth College, Rhyl, and was a student at the University of Liverpool, where he took his medical degree in 1905. He went out to Nyasaland in 1907

to study blackwater fever and was there for two years. In 1911–12 he was again in Africa, this time on a sleeping sickness commission in Northern Rhodesia; in 1914 he was on a similar commission in West Africa. During 1914–29 he held the chair of parasitology at Liverpool, and he was then appointed to the chair of tropical medicine which he occupied until the time of his death on April 24. In 1925 he was awarded the Chalmers Memorial Gold Medal of the Royal Society of Tropical Medicine and Hygiene, and in 1932 he was elected a fellow of the Royal Society.

He married in 1916 Elizabeth Annie Greening and they had two children. He is survived by his wife, a son, now unfortunately a prisoner in Japanese hands, and a daughter. D. B. BLACKLOCK.

PROF. WARRINGTON YORKE knew before the end of last year that he had an inoperable cancer which would be fatal within a few months. Despite this knowledge, he undertook a mission to the United States on behalf of the Medical Research Council and returned with valuable information. Also he undertook to give the Croonian Lecture at the Royal Society on July 15 in the hope that he would live long enough to accomplish it. The title of the Lecture was to be: "Recent Developments in Chemotherapy with Special Reference to Tropical Medicine".

Personally I class his untimely death in the same category as deaths of men 'killed in action', and I recall to myself the brave words written by Robert Louis Stevenson in "An Apology for Idlers"—I believe they were:

"Even if the doctor does not give you a year, even if he hesitates about a month, make one brave push and see what can be accomplished in a week."

S. P. JAMES.

Mr. W. Trevor Watson, K.C.

WILLIAM TREVOR WATSON, who died in his fifty-seventh year on March 24, graduated in the honour school of physics at Oxford in 1909, holding a senior mathematical postmastership at Merton College. In 1911 he was called to the Bar by Gray's Inn, taking a first in the final examinations, and all the prizes that were to be had. He became a pupil and, later, 'devil' of J. Hunter Gray, who at that time was the busiest junior specializing in patent law. During the War of 1914–18 his scientific capabilities were quickly realized and he was transferred from the Worcester Regiment to the R.F.C., where he played a large part in carrying the infant art of wireless telephony to the operational stage between aircraft and ground. A crash suffered in this work undoubtedly had some ill effect upon his health in later life, for he was never physically robust.

On his return to chambers, Watson at once found himself very busy, as he appeared day by day to represent the Treasury in claims before the Royal Commission on Awards to Inventors; in addition, his services were in constant demand in patent litigation in the High Court and in opposition proceedings before the Comptroller of Patents; moreover, he made a reputation as an expert in trade mark and copyright law. He took silk in 1930.

The characteristics which made for his great success were a clear and exceedingly alert mind, keen judgment of the relevant, the gift of explaining difficult scientific matters to those who knew less than he did, and often nothing, while avoiding an air of pedagogy, together with a dignified courtesy to Court and to opponents. He had also a very retentive and accurate memory and the Court accepted without question any statement of the law which he propounded, knowing that he could give chapter and verse without hesitation.

A brief outline only can be given of the scientific detail Watson had to master in the cases he fought, and even this must be incomplete, since no reference can be made to the many problems brought in consultation to his chambers and solved without recourse to litigation. Most of the important inventions of the last twenty years were brought to him for advice at some stage or other. It must be remembered that the understanding of a particular invention is only a minor part of counsel's scientific equipment; he must appreciate so much of the 'common general knowledge' of those skilled in the particular industry that he can evaluate the inventive step which has been made.

The breadth of his knowledge is, perhaps, exemplified by the many inventions brought to the Royal Commission on Awards to Inventors; for example, various radio problems, aeroplanes, mustard gas manufacture, torpedos, paravanes, machine-gun-propeller synchronizing, bomb sights, mortars, grenades, tanks, gyroscopic controls of various kinds. Of his patent cases, mention may be made of the electric lamp cases, the leading-in wire, the coiled-coil filament and the internally frosted globe patents; of the wireless cases, the grid bias and the pentode patents; of the sound-film cases. In the chemical industry, he was concerned in all the rayon litigation, in the hexyl resorcinol case, in the azo-dyestuff case (which established that there may be invention in 'selecting' from a known group for an exceptionally useful purpose) and in the only biochemical case which has come before the Court, the fermentation process for the manufacture of acetone. He also helped to decide whether calcium carbide is legally a synthetic organic chemical or not. Whatever the scientific subject, experts who were cross-examined by him sighed with relief when the battle of wits was concluded and he sat down.

Watson was also a specialist in trade mark and copyright law and was a member of the commission on the advice of which the present trade mark law is founded—though in several respects he disagreed profoundly with the drafting of the present Act.

He remained at all times modest, a delightful companion and interesting talker on many subjects. All who knew him at all well referred to him affectionately as 'Trevor', so that clients have even been known to think he was Mr. Trevor. In later years he took to golf with that thoroughness and competence which he gave to all he undertook. The War made it necessary for him to leave his country house adjoining the North Foreland links, and lack of exercise, the destruction of his chambers in the Temple and the grievous strain of heavy mental work under war conditions impaired his health to the detriment of his accustomed forensic power. It was a great joy to his many friends that in his last case in the House of Lords he recovered all his brilliance, to which the Lord Chancellor, in giving his judgment delivered after Watson's death, made a generous reference. G. S. W. MARLOW.

NEWS AND VIEWS

Copernicus and his Influence on Astronomical Thought

IT is just four hundred years since Copernicus died. A very short time before his death the first printed copy of his work, "De Revolutionibus Orbium Coelestium", was placed in his hands, but in his semi-conscious state he was unable to realize the implications of his views expressed in his book, or the revolution which they were destined to effect in scientific thought. Before his time the Aristotelian scheme of cosmology was generally accepted—the earth being the centre of a system of spheres, to which the planets were rigidly attached. Outside this system was another sphere to which the stars were attached, and this sphere, with the stars, rotated once in twenty-four hours. To account for the erratic motion of the planets it was believed that the planetary spheres rotated in a direction opposite to that of the sphere of stars, but were dragged along by the superior force. Saturn was then considered the outermost planet and therefore nearest to the stellar sphere; for this reason it had the greatest difficulty in overcoming the force of the stellar sphere, and hence required a long time to complete a revolution. In contrast with Saturn the moon—the nearest to the centre—had little force to overcome and so completed a revolution in the least time.

Such, in brief, was the system which Copernicus found when he took up the study of astronomy, and it is against the background of such a cosmology that we must judge his greatness to-day. He introduced simplicity into the generally accepted scheme by postulating a rotation of the earth once in twenty-four hours and an annual motion round the sun. By means of the old devices of eccentricities and epicycles and these two postulates, he worked out the astronomical consequences. Among the ancients there were some who had taught that the earth was in motion, but their ideas were mere philosophical speculations, and they had not developed them into a systematic scheme. To Copernicus alone belongs the honour for the heliocentric scheme which was destined to revolutionize the course of astronomy. In another part of the present issue there appear two synopses of the life and work of Copernicus, which demonstrate the debt that the world of astronomy owes to one who stands out as a great thinker and who made possible the developments which afterwards took place under Kepler and Newton.

Sylvestre-François Lacroix (1765–1843)

IN his "Passages from the Life of a Philosopher", where he refers to the works he studied at Cambridge, Charles Babbage said: "In 1811, during the war, it was very difficult to procure foreign books. I had heard of the great work of Lacroix, on the 'Differential and Integral Calculus', which I longed to possess, and being misinformed that its price was two guineas, I resolved to purchase it in London on my passage to Cambridge. As soon as I arrived I went to the French bookseller, Dulau, and to my great surprise found that the price of the book was seven guineas. After much thought I made the costly purchase, went on immediately to Cambridge, saw my tutor Hudson, got lodgings, and then spent the greater part of the night turning over the pages of my newly-acquired purchase".

The author of this work, Sylvestre-François Lacroix, was for more than half a century one of the foremost teachers of mathematics in Paris, in which city he was born and died. His death took place on May 25 a century ago. A pupil of Monge, his first appointments were in naval and military schools, and then in 1794 he was given an important post in connexion with the re-organization of public instruction. He also held a chair in the short-lived Ecole Normale, and afterwards held professorships at the Ecole Polytechnique, the Collége de France and the Sorbonne, at the last of which at one time he had as colleagues Biot, Poissen, Francœur and Hachette. His book on the calculus was but one of several of his mathematical text-books, but it was probably the most important. Having read his own copy, Babbage drew up a sketch of a society to be formed for translating an earlier and smaller work by Lacroix on the same subject, and thus the Analytical Society came into existence in 1813, Herschel and Peacock being among Babbage's chief supporters. The Society published its translation of the "Traité élémentaire" in 1816, and in the following years the differential notation made its appearance in university examinations.

Smithsonian Institution

THE report of the Secretary of the Smithsonian Institution for the year ending June 30, 1942, includes the financial report of the executive committee of the Board of Regents, together with a summary of the year's activities and reports on the United States National Museum, the National Gallery of Arts, the National Collection of Fine Arts, the Bureau of American Ethnology, the International Exchange Service, the National Zoological Park, the Astrophysical Observatory, the Division of Radiation and Organisms and on the Library. A War Committee has been appointed to facilitate the assistance of the war effort by the Institution, and in addition to preparing a detailed roster of the scientific staff, an index has been compiled of published and unpublished photographs taken by the scientific members of the Institution in all parts of the world for ready consultation by war agencies. Together with the National Research Council, the American Council of Learned Societies and the Social Science Research Council, the Institution has participated actively in setting up the Ethno-geographic Board. Under the editorship of Dr. Julian H. Steward of the Bureau of American Ethnology, the Institution has undertaken the publication of a handbook on the Indians of South America.

Another important Smithsonian publication will be a list of the insects of South and Central America, which will be a much-needed tool for future entomological work in these areas. The specialized geographical, racial and linguistic knowledge of the scientific staff of the Bureau of American Ethnology has been in constant demand by the Army, Navy and other war agencies, but the work of the International Exchange Service has continued to be greatly hampered by the War. The most important event of the year of the Astro-Physical Observatory was the publication of vol. 6 of the *Annals*, covering 1920–39. This volume is the culmination of seven years work on revision of the daily results of observation of the solar constant of radiation at the three field

observing stations. The Division of Radiation and Organisms has continued its work on the factors that influence the change in rates of respiration in plants. The study of the relation between light intensity and inhibition of growth of the oat mesocotyl was extended to higher intensities. Work is in progress on the isolation and separation of two pigments which occur in dark-grown oat seedlings. Since October 1942 the Division has done war work only.

Regional Boundaries in Great Britain

THE Association for Planning and Regional Reconstruction has issued a broadsheet dealing with the regional boundaries of England and Wales. This is of particular interest at the present moment, for it includes a series of maps, the first of which shows the civil defence regions related to a composite of boundaries comprising those of the Ministry of Labour and National Service, the Ministry of Transport, the Ministry of Food, the Board of Education Inspectorate, the Home Office Factory Inspectorate, and the Ministry of Works Contractors Regions, the Ministry of Agriculture Advisory Provinces and Statistical Divisions, the Board of Trade Census of Production 1935 areas, those for the Registrar-General for the Census, and the Post Office regions. The five remaining maps show the divisions suggested by Prof. C. B. Fawcett in 1942, Mr. John Dower in 1938, Mr. E. W. Gilbert in 1941, Prof. E. G. R. Taylor in 1941, and Mr. E. A. A. Rowse in 1941, respectively.

Vitamin Content of Brazilian Foods

ACCORDING to the *Journal of the American Medical Association* of February 20, Dr. Moura Campos, professor of physiology at the University of São Paulo, is conducting a series of researches on the vitamin content of Brazilian foods and on the practical importance of the different vitamins. In a recent paper he showed that thiamine and riboflavin act in association to help in the utilization of the food material by stimulation of the appetite and increase in the assimilation of food. His experiments prove that the presence of thiamine is necessary to the utilization of riboflavin. Thiamine alone cannot maintain the growing capacity. Mandioquinha (*Chærophyllum bulbosum*) contains riboflavin but not thiamine, while goiaba (*Psidium guajava*) contains both thiamine and riboflavin. Experiments showed that the growth of rats was well maintained when they were fed on goiaba alone.

Earthquakes Registered in Spain

DURING January 1943 ten earthquakes were registered by the seismographs at Toledo, Spain (Registro de las observaciones provisionales correspondientes al mes de Enero de 1943. Instituto Geografico. Observatorio Geofisico de Toledo). Eight of these shocks were distant, some being rather feebly recorded and somewhat obscured by microseisms. The shock of January 7 recorded at 11h. 19m. 01s., from an epicentre some 4,445 km. distant, had a probable depth of focus of 100 km. Two shocks were somewhat local. The first, on January 9, began recording with *iPz* at 22h. 00m. 19s. from an epicentre some 318 km. distant and a depth of focus of 25 km. The epicentre was most likely in the Sierra Tejada. The second, on January 21, began recording with *ePz* at 14h. 47m. 17s. from an epicentre some 344 km. distant from Toledo and a depth of focus of 40 km. The epicentre was probably in the neighbourhood of Novelda-Monforte.

Institution of Electrical Engineers: Premium Awards

THE Council of the Institution of Electrical Engineers has made the following awards of premiums: *Institution Premium:* C. J. Beaver and E. L. Davey; *Kelvin Premium:* Dr. F. Brailsford and R. G. Martindale; *John Hopkinson Premium:* Mr. R. A. W. Connor; *Non-Section Premiums:* Dr. E. Friedlander (Ayrton Premium), Mr. C. T. Melling (Llewellyn B. Atkinson Premium), Mr. J. Swaffield (extra premium); *Wireless Section Premiums:* Dr. R. L. Smith-Rose and Miss A. C. Stickland (Duddell Premium), G. Parr and W. Grey Walter (Ambrose Fleming Premium), Prof. Willis Jackson (extra premium); *Measurements Section Premiums:* Lieut.-Col. K. Edgcumbe (Silvanus Thompson Premium), M. Kaufmann and W. Szwander (Mather Premium), G. H. Barker and A. L. Hancock (extra premium); *Transmission Section Premiums:* A. W. Thompson and J. C. Wood-Mallock (Sebastian de Ferranti Premium), A. A. Pollitt (John Snell Premium), H. Willott Taylor and K. L. May (extra premium); *Installations Section Premiums:* G. B. Alvey and N. Tetlow (Crompton Premium), Forbes Jackson, W. J. H. Wood, G. Smith and E. Jacobi (Swan Premium), J. R. Taylor and C. E. Randall (extra premium); *Paris Exhibition, 1881, Premium:* J. N. Waite.

Physical Society: Officers for 1943–44

AT the annual general meeting of the Physical Society held on May 18, the following officers were elected for the year 1943–44: *President:* Prof. E. N. da C. Andrade; *Vice-Presidents:* Dr. J. H. Brinkworth, Prof. C. D. Ellis, Dr. H. T. Flint, Prof. N. F. Mott; *Treasurer:* Dr. C. C. Paterson; *Secretaries:* Mr. J. H. Awbery (*Papers*), Dr. W. Jevons (*Business*); *Foreign Secretary:* Sir Owen Richardson; *Librarian:* Prof. L. C. Martin; *New Members of Council:* Prof. D. Brunt, Dr. B. Chalmers, Brigadier B. F. J. Schonland, Dr. W. S. Stiles. The chairman and secretary of the Colour Group are Mr. J. Guild and Mr. H. D. Murray, respectively; and of the Optical Group, Dr. A. O. Rankine and Prof. L. C. Martin.

Announcements

THE Copernicus Quatercentenary Celebration Committee has arranged a meeting, to be held at the Royal Institution on May 24 at 3.30 p.m. in honour of Nicolaus Copernicus. The meeting will be opened by Sir Henry Dale, and addresses will be given by Prof. Stanisław Kot, Polish Minister of Information, and Dr. H. Spencer Jones.

THE Council of the University of Sheffield has made the following appointments: J. T. Chesterman to be lecturer in surgical pathology and assistant curator of the Museum; Dr. John Sinclair to be lecturer in mining; and T. F. Bamber to be research assistant in mining.

THE following appointments have recently been made in the Colonial Service: S. B. Kendall, veterinary officer, Tanganyika; R. K. J. Gascoigne, entomologist, Sleeping Sickness Control Service, Nigeria, to be agricultural officer, Nigeria; Dr. G. N. A. Hall, veterinary pathologist, Gambia, to be veterinary adviser, Sierra Leone and Gambia (jointly).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

New X-ray Evidence on the Nature of the Structural Changes in Cold-worked Metals

A PROBLEM in X-ray diffraction has been the diffusion of the X-ray reflexions from a metal which has been subjected to plastic deformation. A crucial experiment has long been called for which would indicate clearly what modifications in structure of the deformed metal are mainly responsible for the effect. The method usually suggested is indecisive: it involves a laborious measurement of changes scarcely greater than experimental error, and, as recent publications have shown, gives different results in the hands of different workers[1,2]. It may be of interest, therefore, to record an alternative method which, for a number of metals, including iron and steel, appears to solve the problem in a simple direct manner.

It had already been shown that the systematic deformation of metals in general produces two fundamental effects, either of which could cause the diffusion. These are: (*a*) the breakdown of the metallic grains to crystallites characterized by a lower limiting size; and (*b*) permanent overall changes in dimensions of the atomic lattice to an extent related to the external deformation of the metal[3,4]. The former factor could cause diffusion if the crystallites became less than about 10^{-4} cm. in size, when, with standard diffraction techniques, the number of atomic planes in each becomes too small to produce sharp reflexions; the latter because the lattice strain can produce an overall change in diameter of the diffraction rings, and as the lattice strain is not likely to be the same from point to point, the change in diameter will vary about a mean. Actually it was concluded from other evidence that both effects were usually present, a point especially illustrated by copper; but it was decided to try to develop a reliable criterion to distinguish the predominant factor.

The usual method[1,2] is based on the fact that, with fine crystallite size, the broadening of the reflexions formed at different angles should vary as $\sec\theta$, where θ is the Bragg angle; whereas, for variability of lattice spacing, the broadening should vary as $\tan\theta$. But, in practice, at small values of θ, when $\sec\theta$ and $\tan\theta$ differ most, the broadening is too small for reliable measurement; while at large values of θ, when the broadening does become measurable, the difference between $\sec\theta$ and $\tan\theta$ is too small to be of much use. Moreover, the necessity of having to photograph the whole angular range of the spectrum would restrict the method to a type of specimen unsuitable for serious study of mechanical deformation.

The method now used here utilizes the fact that at a given reflexion angle the broadening due to fine grain is proportional to λ, the X-ray wave-length used to obtain the diffraction pattern; but that due to variability of lattice spacing is independent of wave-length. The success of the method, however, really arises because a technique has been developed for photographing large-scale back reflexions formed by short incident wave-lengths such as molybdenum $K\alpha$ radiation without unduly long exposures, a procedure usually regarded as impracticable. It is then possible to confine attention to the large-angle reflexions, which show the broadening on an easily measurable scale. The wave-lengths normally employed to obtain back-reflexions range from 1·5 to 2 angströms. If a photograph is obtained with one of these as incident radiation and then with molybdenum radiation (λ = 0·7 A.) or a similar short wave-length, then the broadening, if due to fine grain, will change sensitively by a factor of 2 to 3 times, well beyond experimental error.

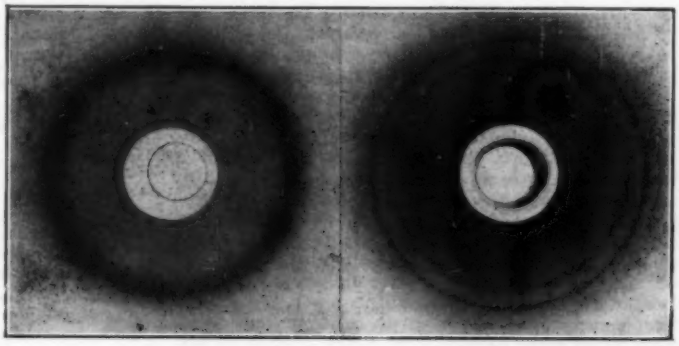


Fig. 1. Fig. 2.

In fact, when the main factor is fine grain, the change is so striking that it may be of interest to illustrate the effect. Fig. 1 shows the very diffuse back-reflexion (310) ring obtained from a heavily deformed steel with cobalt radiation (λ = 1·8 A.); it is too diffuse to show the component $\alpha_1\alpha_2$ doublet. Fig. 2, in contrast, shows a ring at approximately the same diffraction angle with the molybdenum radiation. The $\alpha_1\alpha_2$ doublet now forms rings so obviously sharper that, in any event for steel, the long-standing problem can be solved by inspection.

W. A. WOOD.

Physics Department,
National Physical Laboratory,
Teddington.

[1] Dehlinger and Kochendorfer, *Z. Krist.*, **101**, 134 (1939).
[2] Stokes, Pascoe and Lipson, NATURE, **151**, 137 (1943).
[3] Wood, *Proc. Roy. Soc.*, A, **172**, 231 (1939).
[4] Wood and Smith, *Proc. Roy. Soc.*, A, **178**, 93 (1941); **179**, 450 (1942); **181**, 72 (1942).

Mechanism of Biological Action of Vitamin K and its Synthetic Analogues

THE correlation between structure and biological action of the vitamin K group is an object of many investigations. However, in spite of much experimental material we still lack a satisfactory explanation of both the established correlations and of the mechanism of biological action of the natural vitamins K_1 and K_2 and of their synthetic analogues. It was already in 1939 that L. F. Fieser first suggested the hypothesis[1] further developed in 1941[2] that the

biological activity of most analogues of vitamin K is due not to these substances as such, but to the quinones of the type of the natural vitamin into which they are transformed within the organism as a result of biological synthesis. As to the mechanism of biological action of the vitamin itself, this question remains open. L. F. Fieser's hypothesis is far from being in accord with much experimental evidence, nor does it offer a satisfactory explanation of much of it. At the same time it strikingly contradicts the notion that a perceptible, although slight, anti-hæmorrhagic activity is shown by phthalic acid[3]. This discrepancy is particularly noteworthy in view of the fact established in this laboratory that a high antihæmorrhagic activity is characteristic of the diethyl ether of phthalic acid (the biological assay was carried out by B. A. Kudriashev). The possibility of transformation, within the organism, of phthalic acid into compounds of the 1,4-naphthoquinone series is indeed extremely doubtful.

These observations have given some reason for assuming that the natural vitamins K_1 and K_2 as well as their synthetic analogues are only pro-vitamins, and that their antihæmorrhagic action is due to an *oxidative biodecomposition to phthalic acid*, the latter being the true carrier of the biological function at issue. An especially conclusive argument in favour of this hypothesis is our observation made in this laboratory that such highly active analogues of vitamin K as 2-methyl-1,4-naphthoquinone and potassium 2-methyl-1,4-naphthoquinone-3-sulphonate transform extremely easily into phthalic acid even upon mere heating with water, that is to say under conditions which are most probable within the organism as well. It may be concluded from a detailed study of these transformations as well as from other properties of quinones that biological activity of both natural vitamins K_1 and K_2 and of all their synthetic analogues (derivatives of naphthalene) is actually the function of their capacity to transform into phthalic acid, while the correlations between molecular structure and biological activity can be reduced to the effect of certain structural factors on the processes resulting in the formation of phthalic acid. In our view, transformation of the natural K_1 and K_2 vitamins and their analogues into this acid is only possible in such a molecule where there may arise a tautomeric system (I) ⇄ (II) which is simultaneously an oxidation-reduction system

(I) (II)

where R is hydrogen or a hydrocarbon radical, and R_1 hydrogen, hydrocarbon radical or some other atomic grouping, with quinone as oxidant* transformed into hydroquinone (or into the products of further transformations of the latter), and enol (II) as reductant, finally oxidized to phthalic acid. Thus the appearance of biological activity is primarily determined by the possibility of initiation of the tautomeric system (I) ⇄ (II) and of a series of subsequent oxidation-reduction processes, while the effect of structural factors upon the biological activity is essentially due to their influence upon these transformations.

A discussion from this point of view of the experimentally established correlations between structure and biological activity within the group of vitamin K not only does not contradict the above concept, but also is completely confirmed by the data available. These correlations, in their turn, find an adequate interpretation.

M. M. SHEMIAKIN.
L. A. SCHUKINA.
J. B. SHVEZOV.

All-Union Institute of Experimental Medicine, Moscow-Tomsk, U.S.S.R.

Dec. 16.

* The part of oxidant is possibly played within the organism by other compounds as well.

[1] Fieser, L. F., *J. Amer. Chem. Soc.*, **61**, 3467 (1939).
[2] Fieser, L. F., Tischler, M., and Sampson, W. Z., *J. Biol. Chem.*, **137**, 659 (1941).
[3] Packendorf, K. G., Kudriashev, B. A., and Lazareva, E. N., *Doklady Acad. Nauk USSR.*, **31**, 484 (1941) (Russ.).

Counteracting Sulphonamide Inhibitors

I WAS pleased to learn that Tenenberg, Tsuchiya, Clark and Strakosch[1] have recently confirmed experiments which I conducted in 1940 on the effect of sulphanilamido-urea compounds on sulphanilamide-fast organisms in the presence of inhibitor compounds. These workers have found that combinations of sulphonamide and urea possessed bacteriostatic activity in the presence of the sulphonamide inhibitor compound *p*-aminobenzoic acid, when neither sulphanilamide nor urea by itself showed any effect on bacterial growth.

At the same time I am gratified to note that Mirick[1] has been able to advance further fairly conclusive evidence for the opinions I formed during my studies on inhibitor compounds[2]—which led to the introduction in Great Britain of sulphonamido-urea combinations—that the compound produced by sulphonamide-resistant strains of bacteria which was soluble in water, alcohol, ether and acids and inactivated by bromination, was actually *p*-aminobenzoic acid. At the time there was no chemical method available for identifying with absolute certainty the traces of *p*-aminobenzoic acid produced by these strains and distinguishing them safely from the other similar amino-acids produced by bacterial metabolism. Mirick has, however, by specifically adapting soil bacilli to destroy *p*-aminobenzoic acid, been able to inactivate specifically the inhibitor compound present in sulphonamide-fast pneumococci Type I. He has also been able to activate the *p*-aminobenzoic acid oxidases of these strains of soil bacteria by means of the natural inhibitor compound produced by the sulphonamide-fast Type I pneumococci. No further light has, however, been thrown on my observations that a 1 : 10,000 concentration of 8-methyl α-indole-β-aminopropionic acid in the culture medium of sulphonamide-fast streptococci increased the production of the inhibitor compound considerably, and that the production of the inhibitor compound was greatly retarded on media poor in tryptophane and organic –SH compounds. It seems extremely probable, therefore, that as it has been impossible to prove the presence of greatly increased quantities of *p*-amino-

benzoic acid in the sulphonamide-fast organisms, this inhibitor is excreted rapidly by the sulphonamide-fast strains as a by-product of bacterial metabolism.

The sulphonamide-fast organisms I used to determine which compounds would inactivate the inhibitor substance were strains of *Streptococcus viridans* and *Staphylococcus aureus*. In order to determine the reaction of fairly primitive mesenchymal cells (for example, the histiocytes of the reticulo-endothelial system) and, in that way, to determine the formation of any toxic decomposition product, the sulphonamide-fast bacteria were implanted on to small squares on plasma clots in Carrel flasks, around which tissue cultures (chick periostial fibroblasts) were implanted. The percentage of deaths of the cultures was plotted against time. The sulphonamide-anti-inhibitor compounds were introduced into the same squares and also the organisms per c.c. of the suspension determined.

It was found that the main compounds that were active in sulphanilamide-fast organisms were sulphanilamido-urea, and to a lesser degree sulphanilamido-allantoin, while sulphanilyl-urate was inactive. These compounds also showed the curious phenomenon of increasing the rate of cell-growth and cell-migration of the fibroblasts towards them, even in the absence of bacterial infections, and were of lower toxicity towards the cells than any other of the sulphanilamides tested. In all the above experiments the strains of sulphanilamide-fast streptococci and staphylococci were very susceptible to sulphanilamido-urea, while they were unaffected by either sulphanilamide or by urea as such. The same applies to a slightly lesser degree to sulphanilyl-allantoin. Among other compounds that showed a high activity in these resistant strains were 7 : 7′-(tetrazo 4 : 4′-diamino-diphenyl-sulphone)-1-acetamino-8-naphthol-3.6-disulphonic acid and its sodium salt. This compound, however, to my knowledge, has not yet been tried clinically.

Preliminary clinical reports available from American workers on sulphonamido-urea show that the material offers great possibilities. It is also being claimed that sulphanilamido-urea shows a greater activity towards ordinary bacterial strains and that the toxic reactions that accompany all sulphanilamides are much less pronounced with this combination.

It is too early yet to judge the full significance of the anti-inhibitor compounds in sulphonamide therapy, especially in the treatment of war injuries; but as the number of clinical cases caused by sulphonamide-fast bacteria is gradually and alarmingly increasing, it is becoming a matter of national importance to investigate as wide a range of sulphonamide-fast bacterial strains as possible, in order to determine as soon as possible the extent to which sulphanilamido-urea combinations will be effective in cases where sulphanilamide, sulphapyridine, sulphathiazole and sulphadiazine have been ineffective, partially or wholly, and whether it would prove practicable to introduce immediately for clinical routine anti-inhibitor-radicals into standard sulphonamide drugs.

W. K. S. WALLERSTEINER.

Research Department,
Watford Chemical Co., Ltd.,
London, W.1.
April 21.

[1] *Proc. Soc. Exp. Biol. Med.*, **51**, 247 (1942).
[2] *Amer. J. Clin. Invest.*, **21**, 628 (1942).
[3] *Proc. Roy. Soc. Med.*, **34**, 349 (1941). *Lond. Hosp. Gaz.*, Clin. Supp., 5 (1940).

Amoeba lescherae

WE have already given a preliminary account of a new amœba which we called *Amœba lescheri*[1]. In a subsequent communication[2] we pointed out that, contrary to our first statement, the division of the nucleus was mitotic. Dr. Margaret Jepps has kindly informed us that, according to the rules of nomenclature[3], the specific name should be *lescheræ*, since the amœba was named to honour the memory of Mary Adela Lescher, the foundress of the College of Notre Dame in Glasgow. It is proposed to use this corrected form, *Amœba lescheræ*, in the full and corrected description of the morphology, cytology and life-history which will shortly appear in the *Quarterly Journal of Microscopical Science*.

MONICA TAYLOR.
CATHERINE HAYES.

Notre Dame Training College Laboratory,
Dowanhill, Glasgow. April 24.

[1] NATURE, **145**, 464 (1940).
[2] NATURE, **149**, 501 (1942).
[3] For example, Proc. IXth Internat. Congress, Zoology, Monaco. See Wenyon, "Protozoology", vol. 2, 1336 (1926).

Potatoes and War Economy

DR. COPISAROW[1] has done well to redirect attention at this season to the importance of our being able to produce 'additional' potatoes. Methods of propagation which he cites are the use of 'tops' (for the development of which Prof. Lysenko and his co-workers have recently been awarded the valuable Stalin Prize for Agriculture), of peelings, of 'eyes' (with a small amount of parent tuber attached), and my own preliminary tests with detached sprouts. All of these methods have given satisfactory or at least worthwhile yields, the first having, according to *Pravda* (October 7, 1942), enabled the Russians to increase their total area under potatoes by 100,000 ha. in 1942, in spite of huge losses in territory and materials; the last method, and the possibilities of storage and vernalization of the detached sprouts, would seem especially worthy of detailed study in Great Britain as by it several effective propagules can readily be obtained from a single tuber without noticeable effect on this last even from a culinary aspect. Thus the self-same tubers can be used first for purposes of propagation and then for food.

In view of the vital importance of our main potato crop in war-time and of the significance attached by the two Ministries concerned to the planting of only imported tubers, many people will have been comforted by the recent announcement that far more 'seed' than a year ago has been brought south from Scotland; others, however, are left wondering whether this is all properly certified material and, particularly, how much of it will be used to full advantage. For between the wide extremes of wastefully planting large tubers whole and of cutting them into hazardously small pieces there lies a happy mean which is both economical and practicable. The former of these extremes is all too common in England and follows the persistent selling of uncertified tubers of 'ware' size (in some recorded instances actually *averaging* more than 8 oz. each) for seed at exorbitant prices under the label 'Scotch Class 1'—a practice that, in the absence of proper advice about 'cutting', is to be condemned in warf time as wickedly wasteful of transport as well as o-food or raw materials[2]. The other extreme is exemplified as implied above by the American 'potato-

eye' trade and by the recent practice in Russia of saving and planting the top 10 per cent or less by weight of the larger tubers used in canteens, etc. My own experiments using potato tops and other cut pieces of various sizes and after various treatments indicate that, at least in the absence of favourable weather conditions on which we cannot count, or of laborious early planting in boxes[3], cut pieces of less than 20 gm. weight are unlikely to prove practicable in England except in conditions of extreme shortage of seed. But whether or not, under our very different climatic and present economic conditions, these Russian and American measures could be of commercial value in the British Isles, we should make haste to find out more about their practice and local application in case of emergency when their widespread employment might well save us a million tons of potatoes for food or other purposes.

Meanwhile the economical, practical mean for us lies in the widespread application of such less extreme cutting methods as have long been extensively employed in the United States. This cutting can be done on a large scale mechanically and *inter alia* made to solve our main problem in perfecting an efficient potato planting machine; it would save huge quantities of valuable carbohydrate material which is otherwise put back annually into the soil; it would abolish all need for the laborious and artificial separation of 'seed' from 'ware' tubers; it would help economize fuel and transport; it would speedily reduce 'degeneration', as small tubers tend to be more heavily infected with virus; and it would allow correspondingly better disease control, as more or all of our acreage could, with proper organization and education, be grown from certified stock using large as well as small tubers.

Contrary to popular conception and practice the tubers should be cut across transversely or into square-faced chunks rather than lengthwise—not only, with most strains and shapes of tuber, in order to expose less area to drying and subsequent fungal attack but also because morphologically speaking potato tubers are shoots and only by transverse cutting will the usual backward movement of growth-retarding substances from the dominant sprouts of the (physiological) tip be restricted and sturdy, productive daughter shoots obtained from the 'heel' (proximal) as well as the 'rose' (distal) end. Moreover, contrary to the usual directions given in Great Britain, the pieces if not planted immediately after cutting must be kept *moist* (for example, covered over with damp sacking) at least until they have healed by local deposition of suberin (12-24 hours at about 10° C. usually suffices). Everything considered, sets weighing an ounce or so and planted rather closer together than is usual with whole tubers may be expected to give the most satisfactory results.

NICHOLAS POLUNIN.

Department of Botany,
University of Oxford.
April 27.

[1] NATURE, 151, 421 (1943).
[2] *Gard. Chron.*, 113, 36-7 (1943).
[3] *J. Min. Agriculture*, 50, 20 (1943).

Map Construction from Aerial Photographs

During the early part of the War a need arose for showing how a map can be constructed from aerial photographs. Since no suitable strips of aerial photographs were readily obtainable, strips of imitation aerial photographs were prepared by traversing a fairly large plaster relief model of part of a well-known part of the Western Highlands of Scotland with an ordinary camera kept at a small fixed distance from the base of the model, and maintained with its optical axis normal to the base of the model. The successive positions of the camera relative to the model were arranged so as to give adequate overlap of adjacent photographs and strips. Enlarged prints of a convenient size were made and successfully used for demonstrating the construction of a map from a series of strips of aerial photographs. (It should be noted that the camera had no collimating marks, and therefore the principal point of the photographs was assumed to be at the intersection of the diagonals. No special photographic materials were employed.)

Increasing numbers of people are taking a keen interest in the applications of aerial photographs, and a recent book[1] suggests various exercises. Under war conditions it is not at all easy to obtain photographs which can be used for practising the manipulation of aerial photographs. Hence the above method of making imitation aerial photographs, a method which may possibly have been employed and described by others previously, may be of assistance to those who possess no suitable real aerial photographs.

There seems to be no reason why these imitation aerial photographs should not be used for practising the compilation of mosaics; and when a stereoscope and stereometer are available, contouring might be attempted, the contours being tied to spot-levels determined by means of a cathetometer. Tilted photographs can be made and photographs with short overlap in order to show the difficulties which arise in such cases. Finally, maps compiled from imitation aerial photographs can be checked by comparison with the model.

G. D. HOBSON.

Department of Geology,
Imperial College of Science and Technology,
London, S.W.7.
May 3.

[1] "Aerial Photographs: their Use and Interpretation", by A. J. Eardley (see NATURE, April 24, p. 450).

H. L. Callendar and the Theory of the Liquid State

In 1902, H. L. Callendar[1] suggested that the variation of specific heat of water with temperature could be explained by assuming that a volume of liquid in equilibrium with its vapour contained dissolved in it a number of molecules of its own vapour. The number of molecules assumed to be dissolved was such that, as a vapour, they would occupy the same volume as the liquid, so that the concentration of dissolved molecules in the liquid was the same as that of ordinary molecules in the vapour.

Since Callendar's time, developments in general physical theory have removed the difficulty which he found in accepting a variable specific heat. As a result of X-ray studies, the chemical idea of different 'hydrol' molecules has also been superseded. Nevertheless it is the object of this note to point out that, applied to liquids generally, Callendar's suggestion is precisely equivalent to a later concept which has proved acceptable and capable of useful development.

In 1936, Eyring[2] pointed out that the energy

necessary to make a hole in a liquid just large enough to accommodate a single molecule is equal to the energy required to vaporize a molecule leaving no hole. He showed that to a first approximation the entropy of such a hole in the liquid should be equal to the entropy of a molecule in the vapour, and moreover that the concentration of holes per unit volume of liquid should be equal to the concentration of molecules per unit volume of the vapour. With his collaborators, Eyring has since developed a useful account of the liquid state based on the concept of such holes.

It is very readily seen that the number, energy, entropy and effective size of the holes postulated by Eyring are identical with the number, energy, entropy and size of the dissolved molecules suggested by Callendar. Hence it would not appear justifiable to distinguish between the concepts. In fact, Eyring in his original paper uses the phrase "holes dissolved in liquids", while in the account of Eyring's work given by Fowler[3] the 'motion' of a hole is definitely interpreted as its being successively occupied by neighbouring molecules. Formally, a molecule which is moving into a hole position and forming another one behind it is equivalent to Callendar's "dissolved" molecule. Finally, Kirkwood[4] has proved the formal identity of the hole theory of condensation with the theory of critical solution phenomena.

The later work is, of course, much more elaborate and the concepts more developed, but it seems desirable that Callendar's equivalent expression of the original idea should be recognized.

R. S. SILVER.

G. & J. Weir, Ltd.,
Research Dept.,
Cathcart, Glasgow, S.4.

[1] Callendar, *Phil. Trans. Roy. Soc.*, A, **199**, 147 (1902).
[2] Eyring, *J. Chem. Phys.*, **4**, 283 (1936).
[3] Fowler, R. H., "Statistical Mechanics" (Cambridge University Press, 1936), 845.
[4] Kirkwood, *J. Chem. Phys.*, **7**, 908 (1939).

Science, Common Sense and Decency

IN his strictures on Dr. Langmuir's opinions Mr. Bateman[1] affirms that it is "important to distinguish clearly between concept and reality". I agree. But has not Mr. Bateman confused the issue by his statement that the uncertainty principle "is a concept which has no bearing . . . on the *reality*, which is that at any moment a particle has both a definite position and a definite velocity, and that both are determined by its external and internal conditions". A little reflection will reveal that Mr. Bateman's "reality" (he does not tell us the source of his inside knowledge of this realm) is in fact composed of at least four *concepts*, namely, moment, particle, position and velocity. These objects are merely abstractions derived from our experience of the flux of events; we have no more reason to suppose that natural entities are ultimately composed of 'particles' than that they are bounded by 'lines'; and the status of 'moments' and 'positions' is at least as old as Zeno. What meaning is to be attached to "the internal conditions" of a particle I frankly cannot imagine.

It is, as Mr. Bateman observes, significant that the "resurgence of metaphysics, spiritualism, etc. [rather an ill-assorted pair, even apart from the 'etc.'] . . . has been mostly confined to physicists". But the reason for this is, I suggest, not that they cannot 'see' their entities (has Mr. Bateman ever seen a gene?), but that their more refined modes of analysis—experimental and mathematical—have enabled them to penetrate into realms in which the 'common sense' concepts, such as 'particles', are no longer *adequate*. In some of its reactions an electron reveals itself as having the attribute of 'particularity'; in others it may be more appropriately described as a 'smudge'. It is 'really' both of these aspects, and probably much more. As Dr. Whitehead reminds us, "Undoubtedly molecules and electrons are abstractions. But then so is Cleopatra's Needle"[2].

I should be the last to argue that this 'resurgence' of interest in the problems of philosophy has always been productive of clear thinking, but it *is* significant that it is the physicists who have realized that, to quote Dr. Whitehead again, "Once you tamper with your basic concepts, philosophy is merely the marshalling of one main source of evidence, and cannot be neglected"[3].

WILLIAM P. D. WIGHTMAN.

The Edinburgh Academy,
Edinburgh.

[1] NATURE, **151**, 450 (1943).
[2] "Concept of Nature", 171.
[3] "The Principle of Relativity", 6.

MR. A. J. BATEMAN'S comments[1] on Dr. I. Langmuir's ideas call in their turn for comment from the point of view of a physicist.

That eminent physicists are now proceeding to explore the philosophical bases of their science is a symptom of the fact that physics has now reached a stage when it is becoming possible to see its problems whole, and when certain metaphysical aspects are becoming insistent[2]. It is possible that many biologists, on the other hand, have not yet become aware of the limitations of the scientific method in its classical form.

Physicists fully appreciate the distinction between concept and reality[3], but realize that it does not follow that "as science progresses the gap between concept and reality decreases". It is at least theoretically possible that at any given moment our hypothetical 'world-picture' may be progressively diverging from the underlying reality. Mr. Bateman appears to regard the law of cause and effect as axiomatic, but this is an intuition on his part, and its acceptance is an act of faith, based on extrapolation from macroscopic phenomena. One would not feel justified in dogmatizing about the matter, but we cannot ignore the possibility that the uncertainties in our knowledge of atomic and quantum phenomena may be inherent in the phenomena themselves and not merely due to gaps in our own knowledge.

Presumably nobody would deny that mass effects are statistical integrations (though the meaning of "conflict between probabilities" escapes me), and that we can, for most purposes, ignore "individual idiosyncracies", but it is because we are now trying to account for these idiosyncracies that we must contemplate the possibility that traditional lines of thought may not, after all, be capable of accounting for them in detail.

E. DENNE.

Mid-Essex Technical College
and School of Art,
Chelmsford.

[1] NATURE, **151**, 450 (1943).
[2] Jeans, J., "Physics and Philosophy", Chap. 1 (Cambridge, 1942).
[3] Planck, M., "The Universe in the Light of Modern Physics", 11 (trans. Johnston, W. H., London, 1931).

IMPROVEMENT OF THE NITROGEN STATUS OF SOILS AND THE ORIGIN OF SOIL NITROGEN

By PROF. N. R. DHAR

Indian Institute of Soil Science, Allahabad

IN a communication in NATURE[1] it was reported that farm-yard manure (cow dung), when added to soil, fixes the atmospheric nitrogen, and that the value of cow dung lies not only in its nitrogen content but also in its power to fix atmospheric nitrogen. Field trials have confirmed this observation. That nitrogen fixation or accumulation takes place on the addition of farm-yard manure even in the soil of temperate climates is evident from the following results obtained in the classical field trials at Rothamsted :

	Total nitrogen
1. Receiving no manure since 1843	0·095 per cent
2. Receiving farm-yard manure since 1852	0·256 "
3. Receiving complete artificials including ammonium sulphate	0·099 "

Moreover, we have shown[2] that molasses, different carbohydrates, glycerol, dextrin, cellulosic materials like paper, hay, leaves, fats like butter, *ghee* (clarified butter), salts of palmitic, oleic, stearic, citric, tartaric, malic, oxalic, acetic acids, etc., when mixed with soil or chemical surfaces like the oxides of zinc, aluminium, iron (Fe_2O_3), manganese, nickel, cobalt and copper, can fix atmospheric nitrogen both under sterile and unsterile conditions in presence of air. It has also been observed that the amount of nitrogen fixed per gram of carbon oxidized is much greater in light than in the dark, because light is actually utilized in nitrogen fixation.

Russell[3] has reported that the nitrogen content of grass land increased from 0·152 per cent in 1856 to 0·338 per cent in 1912. Similarly, a land permanently covered with vegetation for twenty-four years showed an increase from 0·108 to 0·145 per cent total nitrogen.

The foregoing observations clearly show that carbonaceous substances help in the accumulation of nitrogen and its fixation, and this explains why organic substances are valuable in steadying crop yield as observed in Rothamsted and other places.

Our experimental results show that the loss of nitrogen, chiefly due to nitrification, when ammonium sulphate is added to the soil is appreciably diminished by the addition of carbonaceous substances, which act as negative catalysts in the oxidation reactions involved in the process of nitrification, leading to a loss of nitrogen mainly in the gaseous state.

In most schemes of husbandry arrangements are made to keep up or even increase the supply of organic matter, while in forests the removal of leaves and other decomposable carbonaceous compounds is undesirable. Němec[4], studying the forests of Czechoslovakia, observed that the removal of the litter lowered the nitrogen content of the soil by 58·6 per cent.

Shutt's analysis of the Indian Head prairie soil, Saskatchewan, shows that after twenty-two years cultivation the percentage of total nitrogen dropped from 0·371 to 0·254. Here there was very little loss due to drainage, yet only a third of the lost nitrogen is recovered in the crop. Similar results have been reported with Minnesota and Kansas soils. Great tracts in the United States and in Canada, stable in their natural state, have been rendered liable to erosion by over-cultivation and fallowing and by grazing. Both on the cultivated and on the grazed land, the organic matter (carbonaceous substances) of the soil was rapidly destroyed by oxidation, causing a rapid loss of nitrogen as stated above. The effect has been an unprecedented destruction of the soil in recent years, not only by erosion but also by the loss of organic matter and total nitrogen due to rapid oxidation involved in the nitrification of proteins and other nitrogenous compounds.

In our recent experiments on nitrogen fixation the following results have been obtained[5] :

With numerous carbohydrates it has been found that even under completely sterile conditions the nitrogen fixed per gram of carbon oxidized in quartz vessels exposed to light with soil is 12·2 mgm., in glass vessels exposed to light it is 10·7 mgm., while in the dark it is approximately 4·5 mgm. per gram of carbon oxidized. The order of these fixations under sterile conditions is practically the same as obtained in unsterile soils. With the oxides mentioned above used as chemical surfaces instead of soil, and glucose as energy material, the nitrogen fixation per gram of carbon oxidized is of the order of 15–18 mgm. in light under completely sterile conditions, while in the dark it is 8–11 mgm. Under unsterile conditions the fixation in light varies from 30 to 46 mgm. and in the dark from 15 to 24 mgm. per gram of carbon oxidized. Moreover, recent experiments carried on with sterile and unsterile soils mixed with carbohydrates and other energy-providing materials show that the velocity of the oxidation of carbon in the carbonaceous compounds under completely sterile conditions is about a third to a half of that under unsterile conditions. It seems that nitrogen fixation can take place not only with the help of Azotobacter but also in the complete absence of bacteria, as a surface process aided by sunlight ; and the chief source of nitrogen in soils in all countries is this type of fixation and not legumes as is believed to be the case in temperate climates.

This conclusion is partly corroborated by the following observation of Morse[6] with soils containing approximately 0·15 per cent total nitrogen. Analysis of soil from experimental plots of twelve years standing in Massachusetts showed no evidence of accumulation of nitrogen by the application of nitrogen fertilizers or by the growth of leguminous crops, nor did continuous production of non-legumes appear measurably to deplete the soil of nitrogen. Soil nitrogen varied irregularly from year to year, showing no special tendency to increase or decrease in any plot.

The higher value of the efficiency of nitrogen fixation obtained with oxide surfaces as compared with that obtained in soils is due to the fact that the phenomena of nitrogen fixation and nitrogen-loss go on simultaneously ; the fixation process is being opposed by the loss due to nitrification. Ammonium nitrite, which is unstable, is formed in the process of oxidation involved in the nitrification of the proteins and other nitrogenous compounds produced by fixation or originally present in the system (compare Dhar[7]). But in soils, there is already a certain amount of combined nitrogen—to the extent of 0·04–0·05 per cent in tropical soils—and hence the loss of nitrogen is more marked than when oxide surfaces are used containing no nitrogen. Apparently therefore the efficiency of the process of nitrogen

fixation is much better in presence of oxide surfaces than in the soils containing nitrogen. These observations are of fundamental importance in explaining the evolution of fertile soils from the parent rocks. The geological deposits, that is, the parent materials of soil, do not contain organic matter, but can contain inorganic nitrogen in the form of nitrates or of ammonium salt in very small quantities. The nitrates can under the influence of light and moisture together with seeds form the first plant life or algæ, the nitrogen need of which is met from the inorganic nitrogen originally present in rocks in small quantities. The carbohydrates and cellulosic materials or other energy-producing materials formed in photosynthesis undergo decomposition in course of time and are oxidized, causing nitrogen fixation in this process, which is aided markedly by light absorption, and thus the store of nitrogen in the system is increased. This in its turn leads to a more abundant growth of vegetation, and the process goes on in which the carbon and nitrogen status of the system is improved, leading to the formation of a fertile soil. This nitrogen fixation, which in the beginning at any rate is a non-biological surface reaction, is aided by light absorption, because light is utilized in this process. As the original mineral is poor in nitrogenous compounds, the nitrogen fixation is greatly enhanced in the beginning, but with the storing up of nitrogen the efficiency falls off and thus the nitrogen and carbon status of the soil reaches a maximum depending on the climate of the region. As a matter of fact, much more nitrogen is fixed in soils in this manner by light absorption than the amounts fixed in all the industrial processes taken together.

The organic matter in the soil may also be caused by the growth of alga. It is believed to be valuable in most circumstances, but on newly formed soil it is of the greatest importance. The carbon of decaying algæ is oxidized and the energy liberated leads to the fixation of atmospheric nitrogen.

The residual effect of cow manure as observed throughout the whole world may be due, not mainly to the conservation of nitrogen as hitherto believed, but to the fixation of atmospheric nitrogen through the oxidation of energy-producing materials like pentosans, celluloses, fats, etc., and aided by the absorption of sunlight. It seems that wherever a residual effect of a nitrogenous manure has been observed, for example, with molasses, hay or cow manure, it is chiefly due to nitrogen fixation in the soil; possibly no residual effect would be observed with a manure which is incapable of fixing atmospheric nitrogen, although it may contain carbon. It seems that so far no worker has reported that legumes leave as much residual effect as cow or farm-yard manure or molasses.

In Indian soils under cultivation, as well as in those of other tropical countries, the total nitrogen is much lower than in the soils of temperate countries. This is due to the fact that the prevailing high temperature and intensity of sunlight accelerates the oxidation of carbonaceous and nitrogenous compounds in tropical soils, thus entailing a loss of nitrogen caused by the nitrification of protein and other nitrogen compounds. But when the land is covered with grass or other vegetation, this oxidation can be retarded and the loss of nitrogen diminished, with the result that the nitrogen content can be raised. With cultivation, however, the nitrogen-level again falls down to the normal. By the addition of organic matter or covering with grass, the nitrogen content is raised both due to the fixation of atmospheric nitrogen and to its conservation in soil.

There is, however, one advantage of the high intensity of light and heat falling on tropical soils. The available nitrogen, that is, the sum of ammoniacal and nitric nitrogen, is much greater in tropical soils than in temperate ones, because of the greater facility of the oxidation of organic and nitrogenous substances in the former. Thus while the available nitrogen in tropical soils is about 10–30 per cent of the total nitrogen (0·04–0·05 per cent), the amount of available nitrogen in temperate country soils is only 1–2 per cent of the total nitrogen (0·1–0·2 per cent) present in the soil. This explains why a better crop can be grown in unmanured fields in tropical countries than in the unmanured fields of temperate countries under comparable conditions. Assuming that an acre of normal soil 9 in. deep weighs 1,000 tons, the amount of total nitrogen in European soils will be about 2,250 lb. per acre, while in Indian soils it is approximately half, namely, 1,125 lb. per acre. But the amount of available nitrogen per acre in European soils may be only 22·5 lb. whereas in Indian soils it is about 112·5 lb. per acre. The concentration of the dissolved nitrate and ammonium salts in soil solutions in the tropics is greater than in temperate climates, and hence the absorption of these nitrogenous compounds by plant roots is much greater in a short time than in temperate climates. By adding molasses or easily oxidizable carbonaceous substances like cow dung, hay, etc., to the soil, the nitrogen content is improved by nitrogen fixation. Along with the improvement in the nitrogen content of the soil the available nitrogen also increases, thus making the soil more fertile. From our experiments with numerous molassed fields in Allahabad and elsewhere, we have observed that, a month or five weeks after the addition of molasses, not only is the total nitrogen content of the soil highest but also the nitric and ammoniacal content of the soil is the highest; and that is the time when a crop has to be sown in the field.

In temperate climates an attempt should be made to improve the available nitrogen content by breaking the soil and exposing it to light and air in the spring, summer or autumn when the sunlight is of high intensity. This will, no doubt, lead to an increase in the amount of ammonium salts and nitrate, but during the process of nitrification a certain amount of nitrogen may be lost in the gaseous state. But this loss may not affect appreciably the soil fertility because of the large amount of total nitrogen present in such soils. Loss due to the escape of free ammonia cannot be marked specially in temperate climate, in view of the fact that such soils have a tendency to be acidic. Instead of adding ammonium sulphate to soils in temperate countries to increase the available nitrogen, it may perhaps be less expensive, especially under the present conditions, to increase the ploughing and breaking up of the soil, making conditions more favourable for oxidation and nitrification and obtaining a better crop yield without making the soils more acidic, as happens on the addition of ammonium sulphate. In the case of soils in temperate climates which have deteriorated and gone out of cultivation, it seems certain that the remedy lies in the addition of cow manure (farm-yard manure) or other readily decomposable carbonaceous substance like molasses, hay, etc., rather than by the addition of legumes, which seem to have not much

residual effect on soils. If a quick result is not expected, wasted or deteriorated land can be improved from the nitrogen point of view by covering it with vegetation or grass and leaving it undisturbed for a number of years. In this way the carbonaceous substances from the decaying vegetation are oxidized and assist in the fixation and conservation of soil nitrogen; thus the nitrogen status is improved.

[1] Dhar and Mukerji, NATURE, **138**, 1060 (1936).
[2] Dhar, presidential address to the National Academy of Sciences, December 1935 and January 1937.
[3] Russell, "Soil Conditions and Plant Growth" (1931), p. 362.
[4] Nemec, *Forstwiss. Cbl.*, **53**, 49, 147 (1931).
[5] Dhar and Seshacharyulu, *Proc. Nat. Acad. Sci. India*, **11**, 97 (1941).
[6] Mérne, *Mass. Agric. Exp. Sta. Bull*, No. 33 (1936).
[7] Dhar, NATURE, **134**, 572 (1934).

THE TENNESSEE VALLEY AUTHORITY

AN EXPERIMENT IN REGIONALISM

By K. S. LOMAX

IT was on May 18, 1933, that the Act of Congress setting up the Tennessee Valley Authority became law. Through lack of effective planning to meet the successive floods, through unscientific farming and consequent loss of rich top soil, depression and destruction had spread throughout the valley of the River Tennessee and its tributaries—an area almost as large as England, with abundant natural resources including iron ore, coal, oil, timber, chemicals, fertilizer constituents, ceramic and aluminium clays, pigments and abrasives. Little was done until Franklin D. Roosevelt was elected president in 1932, and he suggested to Congress legislation to create a Tennessee Valley Authority. In 1933 the system consisted only of the Wilson Dam and nitrate plant at Muscle Shoals which had been started to satisfy the need for nitrates in 1917 and had a capacity of 39,000 kw. Now in 1943 projects are under construction which will increase the capacity of the system to more than two million kw., provide flood control storage of 15 million acre-feet and a nine-foot navigational channel from the mouth of the Tennessee to its upper reaches at Knoxville, 650 miles away.

Flood control, navigation, and the production of cheap and plentiful electric power are not the only activities of the Tennessee Valley Authority. It is a unique experiment in regional development. Its subsidiary activities include the development of agriculture, soil conservation, the encouragement of animal husbandry, the re-forestation of denuded areas, the development of phosphate fertilizers, investigation of the mineral resources of the area, the development of native kaolins for use in high-grade pottery, the development of additional uses for electricity in agricultural processes, the encouragement of co-operatives for collecting, grading and marketing agricultural products, the encouragement of recreational areas, the improvement of housing, education, and public health throughout the area.

The history of the Tennessee Valley Authority, however, has not been without controversy. There were forty-one law suits in the first five years of its existence, two being taken to the Supreme Court, where the T.V.A. was upheld on all counts. It was established that utilities had no monopoly and the Government had the right to sell electric power from flood control dams in competition with private interests. Then in 1939 difficulties arose within the board of three which managed the Authority, the chairman accusing his two colleagues of moral and ethical lapses. The outcome was that President Roosevelt dismissed the chairman and Congress ordered an investigation into the affairs of the T.V.A. The majority report of this inquiry cleared the Authority of the charges against it and concluded that "The Authority should be regarded as a settled and established institution in the Valley. Its construction programme should be carried to completion so that money already invested may not be wasted or inadequately supported by revenue. The agricultural, forestry, public health and other regional development programmes of the Authority are generally acknowledged to be beneficial to the region and to the nation as a whole and should be continued. The Authority has already demonstrated the value of unified river control under public management. It is on the way to full demonstration of the practicability of promotional rates for domestic electric service which may be adopted as well by private utilities as under public ownership."

The T.V.A. experiment has been called "costly". It has been argued that it benefits a fraction of the country at the expense of the rest and that it introduces Government competition with private enterprise. It has been questioned whether a single authority can deal adequately and efficiently with such diverse objectives as navigation, flood control, power production and the many subsidiary activities. The bitterest animosity has been caused, however, by the policy of using T.V.A. power as a "yardstick" to determine "fair" prices for power privately generated elsewhere.

On the other hand, the T.V.A. is a bold imaginative scheme of regional development. It indicates a new approach to the problems of such an area, and its achievements have already been notable, not least among these being the raising of the standard of living throughout the Valley. There are obvious economies to be gained from a multi-purpose project applied to such a large natural system, and there are great advantages in being able to transfer organization and equipment from one dam construction project to another. Undoubtedly an important factor in the ability to produce abundant power at low cost is the fact that the Tennessee Valley Authority was started in a period of depression when labour and materials were cheap.

One of the most significant factors in T.V.A. development and one which we, thinking in terms of post-war reconstruction and possible reform of the structure of local government, will watch with special interest is the technique of administration. There are many units of local government in the area—the Authority embraces, for example, seven States and one hundred countries—and while the T.V.A. is above them it does not supersede them. The official relationships between the T.V.A. and the States, counties, districts, and municipalities of the area are many and varied, ranging from informal agreements to detailed legal contracts. There has been from the start a high degree of co-operation between the T.V.A. and both the local units of the area and also other Federal agencies, and it can be said that an unusual degree of initiative on the part of local units and of citizen participation has been encouraged. The third annual report of the T.V.A.

puts it admirably: "The planning of the river's future is entrusted to the T.V.A. The planning of the valley's future must be the democratic labour of many agencies and individuals and final success is as much a matter of general initiative as of general consent. The T.V.A. has no power or desire to impose from above a comprehensive plan for the social and economic life of the Valley."

INSULATION OF HEATING SYSTEMS

A. C. PALLOT gave a Cantor Lecture to the Royal Society of Arts on "Thermal Insulation at Medium Temperature" on November 23; the lecture, which included many topics of current interest, has now been published[1].

In a bulletin on heat insulation issued by the Ministry of Fuel and Power, it was pointed out that "In the national drive for fuel economy there is probably no single factor, which is common to all industries using heat in its many diverse applications and can produce a greater saving in fuel, than efficient insulation. The reduction of heat loss by insulation is a practical means of achieving a substantial economy in fuel by using materials which are available and can generally be easily and quickly applied without interruption to operation or to process routine"[2]. Comparative neglect of insulation is apparent in many industrial, commercial, and domestic buildings. In some industrial premises taken over by the Government, all the calorifiers, pipes and connexions were devoid of lagging, long lengths of main steam piping were exposed to the weather and were completely bare, and the entire condensate was allowed to run to waste.

The temperature range 100–400° F. covers all normal heating, ventilation and hot-water supply systems, as well as many industrial steam installations, accounting for the use of 60 million tons of fuel yearly—a quarter of the total output of Great Britain. Even a small fractional saving of fuel by the use of insulation would mean a substantial economy in national resources. Many quantitative data given in the lecture show that a highly polished metal surface is quite a good insulator. A given thickness of insulation is more effective on a large pipe than on a small one. 'Insulation' with unsuitable materials may actually increase the heat loss from small-diameter pipes. The first layer of insulation is more effective than subsequent layers in spite of the fact that a greater volume of insulating material is needed for each successive concentric ring. Insulating materials in common use vary from crumpled aluminium foil, reducing radiation losses, to asbestos, magnesia, glass silk and slag wool, reducing losses by conduction. Even aluminium paint will save about half the normal radiation losses. Under ordinary conditions the domestic 25-gallon cylinder loses heat by radiation equivalent to about 5 lb. of fuel a day. Insulation of such a cylinder in constant use would save about half a ton of fuel per annum.

The physical factors affecting heat losses are simple compared with those involved in calculating the economic thickness of insulation. A calculation made of the thickness of a given insulator needed to save a definite percentage of the bare surface loss shows that the thickness diminishes as the temperature increases. This is contrary to ordinary practice, but the 10 per cent of heat still lost through the insulation increases rapidly with the working temperature and a thinner layer of insulation will allow this to pass. A calculation of the most economical thickness of insulation will have to take account of the annual cost of the heat produced and the interest and depreciation charges on the proposed insulation. Both internal and external temperatures will vary throughout the day as well as throughout the year. The cost of the heat lost will depend upon both the cost of fuel and upon boiler efficiency. Hours of operation per annum must be considered, for the loss of heat is continuous while the boiler is in use, but some plants work throughout the year whereas others work seasonally or intermittently. Among these factors the thermal conductivity is the simplest occurring in the calculations, examples of which are given. Special attention is given also to the use of emergency materials as substitutes for orthodox insulator which may be unobtainable in war-time.

In the second part of the lecture, dealing with the insulation of structures, it is pointed out that the modern tendency to build light structures may considerably increase the amount of fuel needed to keep their interiors at a comfortable temperature. Not only will thin walls and roofs allow easy transmission of heat but also, if the walls are at a lower surface temperature, a higher air temperature must be maintained inside. In a well-planned building the initial cost of insulation may be more than offset by the reduction in initial cost of a central heating system as well as by the subsequent reduced consumption of fuel. In addition to its thermal results, the insulation of buildings minimizes condensation, because of the higher surface temperatures. 'Pattern staining', due to the transfer of dust from the warmer to the colder areas of plaster, is reduced, and most thermal insulators are effective in absorbing sound. Furthermore, insulation of concrete roofs reduces expansion, which sometimes causes structural damage.

[1] *J. Roy. Soc. Arts*, **91**, 122 (1943).

[2] *Mines Dept. Fuel Efficiency Bulletin*, No. 2 (1942).

PREPARATION OF TEACHERS IN HEALTH EDUCATION

IT will be a happy day when we have in Great Britain a booklet corresponding to "Opportunities for the Preparation of Teachers in Health Education", issued by the U.S. Office of Education (Bulletin 1942, No. 1). Written in the form of a survey of twenty Teachers Colleges, ranging from Massachusetts to California, this work presents a bird's-eye view of the training of U.S. teachers in this vital subject. It is clear that "health education" is conceived by the U.S. Office of Education as something very different from the traditional 'hygiene', and it is to be hoped that as a result of the deliberations of the Board of Education's McNair Committee on the Training of Teachers, a similar breadth of vision will permeate the training colleges of Great Britain.

Among the obstacles to the achievement of adequate health education courses in the United States are listed the slowness of administrators to recognize the need for them and the lack of well-prepared health instructors —two causes potent also on this side of the Atlantic. Every training college lecturer and administrator in Great Britain should study carefully these detailed

descriptions of twenty courses, and none can fail to reap some benefit from their reading.

A fairly typical programme is that of the San Diego State College in California, which offers courses (some "Required", some "Elective") in the science of life, health and social adjustments, human physiology, physiology of exercise, safety education, general bacteriology, embryology, genetics, mental hygiene, physiology of reproduction, physiology of infancy and childhood, and man and his biological world. No doubt at San Diego as elsewhere, achievement falls short of ideal, but at least the ideal is a high one.

An appendix gives details of colleges and universities in the United States offering courses in health education during the summer session of 1941. No fewer than forty-six are listed—whereas in Great Britain educationists wishing to equip themselves in this field during the summer vacation will be very largely dependent upon courses arranged by bodies such as the Central Council for Health Education.

The U.S. Office of Education is by no means satisfied with the state of affairs shown by this investigation. "Far too many pseudo-health educators and semicultists hold positions of responsibility in the public schools to-day simply because school administrators have either been unwilling or unable to lend themselves to this problem of teacher preparation in health education"; and it is equally true in Great Britain that this "should be sufficient reason why in these stirring times every effort should be put forth to improve on the present situation".

FORTHCOMING EVENTS

Saturday, May 22

NUTRITION SOCIETY (at London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 10.30 a.m.—Conference on Nutrition in Infancy.

BRITISH INSTITUTE OF RADIOLOGY (at 32 Welbeck Street, London, W.1), at 2.15 p.m.—Annual General Meeting.

FREE GERMAN INSTITUTE OF SCIENCE AND LEARNING (at 16 Buckland Crescent, London, N.W.3), at 5 p.m.—Dr. G. Coumoulos: "The Greek Scientists—Traditions and Ties".

Monday, May 24

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Prof. H. V. A. Briscoe: "Some New Properties of Inorganic Dusts" (Cantor Lectures, II).

COPERNICUS QUATERCENTENARY CELEBRATION COMMITTEE (at the Royal Institution, 21 Albemarle Street, London, W.1), at 3.30 p.m.—Meeting in honour of Nicolaus Copernicus. (Sir Henry Dale, P.R.S., will open the meeting, at which Prof. Stanislaw Kot and Dr. H. Spencer Jones, F.R.S., will deliver addresses).

Tuesday, May 25

ROYAL COLLEGE OF PHYSICIANS (at Pall Mall East, London, S.W.1), at 2.45 p.m.—Air Commodore C. P. Symonds: "Flying Stress" (Croonian Lectures, 1).

Wednesday, May 26

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Mr. John Gloag: "The Influence of Plastics on Design".

INSTITUTE OF WELDING (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. H. W. G. Hignett: "Welding Research and Development in the United States of America".

Thursday, May 27

ELECTRICAL ASSOCIATION FOR WOMEN (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 2 p.m.—Annual General Meeting; at 3.30 p.m.—The Rt. Hon. Viscount Samuel: "An Electrified Future".

ROYAL COLLEGE OF PHYSICIANS (at Pall Mall East, London, S.W.1), at 2.45 p.m.—Air Commodore C. P. Symonds: "Flying Stress" (Croonian Lectures, 2).

Friday, May 28

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5 p.m.—Miss L. Evelyn Cheesman: "The Island of New Guinea".

Saturday, May 29

FREE GERMAN INSTITUTE OF SCIENCE AND LEARNING (at 16 Buckland Crescent, London, N.W.3), at 5 p.m.—Capt. Helmer Dahl: "Norwegian Universities and Schools—Past, Present and Future".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

OCCUPATIONAL THERAPIST TO TAKE CHARGE OF THE SCHOOL OF OCCUPATIONAL THERAPY—The Medical Superintendent, St. Andrew's Hospital, Northampton (May 28).

ASSISTANT LECTURER IN CHEMISTRY—The Bursar and Acting Registrar, University College of North Wales, Bangor (May 29).

LECTURER IN CHARGE OF THE BIOLOGY DEPARTMENT—The Principal and Clerk to the Governing Body, Wigan and District Mining and Technical College, Wigan (May 29).

DIETICIAN (NON-RESIDENT) TO ASSIST MEDICAL STAFF IN DIETARY OF IN- AND OUT-PATIENTS at West Middlesex County Hospital—Medical Superintendent 'R.2', West Middlesex County Hospital, Isleworth (May 29).

LECTURER IN MATHEMATICS—The Secretary, Woolwich Polytechnic, Woolwich, London, S.E.18 (May 31).

TWO TEACHERS TO TAKE EITHER (1) METALWORK OR (2) SCIENCE AND MATHEMATICS, in the Junior Technical and Day Continuation Schools—The Organizer of Further Education in Rugby, College of Technology and Arts, Eastlands, Rugby (May 31).

WOMAN GARDENER (non-resident) to prepare students for Horticulture as a subject of the Teachers' Certificate—The Principal, The Training College, Hereford (May 31).

CHAIR OF ELECTRICAL ENGINEERING—The Secretary and Registrar, The University, Bristol (June 1).

LECTURER IN ENGINEERING DRAWING, including the teaching of Workshop Practice and/or General Engineering Subjects, in the Oxford Schools of Technology, Art and Commerce—The Chief Education Officer, City Education Office, 77 George Street, Oxford (June 2).

TEACHER OF MATHEMATICS, and a TEACHER OF ENGINEERING DRAWING AND PRACTICAL GEOMETRY—The Principal, Technical College, Church Street, Barnsley (June 5).

TEACHER FOR MATHEMATICS AND MECHANICS in the Technical School—The Director of Education, City Hall, Norwich (June 5).

ADVISORY OFFICER IN PLANT PATHOLOGY (PLANT HUSBANDRY)—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow (June 5).

DEMONSTRATOR, (MAN OR WOMAN) IN THE PHYSICS DEPARTMENT in London—The Warden and Secretary, London (Royal Free Hospital) School of Medicine for Women, Reed Hall, Streatham Drive, Exeter (June 15).

DIRECTOR OF THE TRANSVAAL MUSEUM, Pretoria—The Secretary, Office of the High Commissioner for the Union of South Africa, South Africa House, Trafalgar Square, London, W.C.2 (June 26).

LECTURER IN ANIMAL HUSBANDRY at the Imperial College of Tropical Agriculture in Trinidad—The Acting Secretary, Imperial College of Tropical Agriculture, Grand Buildings, Trafalgar Square, London, W.C.2 (June 30).

LECTURER IN GEOGRAPHY AND MATHEMATICS—The Principal, The Training College, Norwich.

A SENIOR POST UNDER THE AERONAUTICAL INSPECTION DIRECTORATE (applicants should possess a degree in physics or recognised equivalent and have an extensive knowledge of non-metallic materials, with a specialized knowledge of the production of Paints and Allied Products; Rubbers—Natural and Synthetic; Aircraft Dopes; Plastics, Glues, Cements; or Aircraft Textiles)—Ministry of Labour and National Service (Ref. A.224), Alexandra House, Kingsway, London, W.C.2.

HORTICULTURAL INSTRUCTOR for Boys' Intermediate Approved School—The Headmaster, St. Joseph's School, Nantwich, Cheshire.

GENERAL SECRETARY of the Institution of Production Engineers—Selection Committee of the Institution, 36 Portman Square, London, W.1.

MECHANICAL SUPERINTENDENT for the Ceylon Government Irrigation Department—Ministry of Labour and National Service, Central (Technical and Scientific) Register (Ref. C.1662), Alexandra House, Kingsway, London, W.C.2.

SENIOR ASSISTANT DRAINAGE AND IRRIGATION ENGINEER for the Government of Sierra Leone—Ministry of Labour and National Service, Central (Technical and Scientific) Register (Ref. F.595), Alexandra House, Kingsway, London, W.C.2.

CHIEF INSTRUMENT ENGINEER (Ref. C.1420) and an ASSISTANT INSTRUMENT ENGINEER (Ref. C.1663X) for work at Trinidad, British West Indies—Ministry of Labour and National Service, Central (Technical and Scientific) Register, Alexandra House, Kingsway, London, W.C.2.

ROAD ENGINEER for the Government of Kenya Public Works Department—Ministry of Labour and National Service, Central (Technical and Scientific) Register (Ref. E.656), Alexandra House, Kingsway, London, W.C.2.

DEMONSTRATOR (MALE) IN THE DEPARTMENT OF BIOLOGY—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.C.2.

TEACHER OF MATHEMATICS, MECHANICS AND ELEMENTARY SCIENCE, a TEACHER OF ENGINEERING (MECHANICAL) SUBJECTS qualified to take Workshop Practice, and a TEACHER OF BUILDING SUBJECTS—The Principal, Erith Technical College, Belvedere, Kent.

ASSISTANT MASTER FOR MATHEMATICS AND SCIENCE, WITH PHYSICAL TRAINING AND GAMES, at the Atkinson Road Junior Technical School, Newcastle-upon-Tyne—The Director of Education, City Education Office, Northumberland Road, Newcastle-upon-Tyne 2.

LECTURER IN SCIENCE—The Principal, Hockerill College, Bishop's Stortford.

LABORATORY ASSISTANT FOR WORK IN BIOCHEMISTRY DEPARTMENT—The Secretary, London Hospital Medical College, Turner Street, London, E.1.

ASSISTANT CULTIVATION OFFICERS—The Executive Officer, Cumberland War Agricultural Executive Committee, 6 Brunswick Street, Carlisle.

CHIEF INDUSTRIAL PLANNING OFFICER UNDER THE GOVERNMENT OF INDIA FOR SURGICAL INSTRUMENT PRODUCTION—The Ministry of Labour and National Service, Central (Technical and Scientific) Register (Ref. C.1644), Alexandra House, Kingsway, London, W.C.2.